



# The Journal of Bone and Joint Surgery

## PRESIDENTIAL ADDRESS \*

BY FRANK D. DICKSON, M.D., KANSAS CITY, MISSOURI

Those who are familiar with the Presidential Addresses which were delivered before the American Orthopaedic Association during the first fifty years of its existence know that, while they were almost infinite in variety, the theme of each had a background of science, of history, or of philosophy. In the past two years, however, there has been a change in the character of these addresses; a new note has been sounded. This new note has been one of questioning,—questioning as to the attitude of the American Orthopaedic Association toward the changing conditions which are rapidly developing in medicine, in its sociological aspects; questioning as to the future position of the American Orthopaedic Association in the orthopaedic galaxy. The sounding of this new note is undoubtedly due to the rapidly changing social conditions under which we are living today and changes in the pattern of orthopaedic surgery, the natural result of its growth and progress. This change in the theme of the Presidential Address seems significant. It indicates, I believe, that this Association has not become static and contented with its years, but, on the contrary, is still quick, virile, and aware of the basic changes in medical practice and social conditions which are taking place, and alive to the new responsibilities which, in consequence, are being thrust upon it. Because, then, of the changing conditions within and without the specialty, it would seem that, for the next few years at least, your President in his Address must needs forsake the pattern of the past and direct his remarks toward placing before you the current problems and activities of the Association with such comments upon them as may suggest themselves to him. Stated in another way, the Presidential Address of today must be a sort of document upon the state of the Association. It is in line with this thought that I propose to discuss some of the problems which seem to confront this organization, some of the things which have been accomplished during the

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past year, and some things which, perhaps, still need doing,—all of these from the point of view of one who has for the past several years been in close contact with the concerns of the Association.

First, as to the position of the American Orthopaedic Association toward the present-day trend in government, which is definitely in the direction of dispensing medical relief over a broader base and enlarging the field of the Public-Health Service. Unquestionably, the American Orthopaedic Association, as a responsible body, should keep in close touch with all agencies, state and national, which are attempting to better the care of the physically handicapped. The membership of this Association is made up largely of individuals whose years of service have provided them with a wide experience and have developed in them a mature judgment which admirably fits them to give practical and constructive advice as to the most effective method of dealing with social security and medical relief as related to the physically handicapped. This reservoir of information should at all times be available to those national and state organizations interested in what has been termed "Beneficial Reforms", if they desire to avail themselves of it. Such guidance might perhaps help them avoid the pitfalls ever to be found in the pathway of progress, unless the road is well engineered and well marked. I know of no organization better fitted to engineer and mark this pathway than the American Orthopaedic Association. But the Association should do more than this. It should keep an alert eye upon all national proposals concerned with medical practice, for the implication cannot be avoided that whatever changes are brought about in medical practice in general will be reflected in the special branch of medical practice in which we are so deeply interested. A new social order is developing in our country. Medical practice has been swept into this movement and seems destined to undergo what may be fundamental changes. In view of this situation, it behooves all responsible medical groups to subject to close scrutiny all proposals for the reorganization of medical care on a national basis. We must not be guilty of taking an intransigent attitude, but this does not necessarily imply blind acceptance of every innovation proposed. Many alleged "Beneficial Reforms" put into effect under emotional stress or from political motives have resulted in lessening rather than in increasing social benefits and in chaos, where order and efficiency formerly prevailed. Let us be cooperative to the fullest extent with all governmental agencies, but at the same time let us insist that the quality of medical care must not be sacrificed for the sake of wider distribution of medical service. This, in its final analysis, means resistance with all the force we can muster to attempts to remove medical practice from professional control and to place it under bureaucratic control. This Association has a special committee appointed to study the relationship of the American Orthopaedic Association to the various governmental agencies interested in the care of the physically handicapped. I should recommend that this committee be continued and that its activities be enlarged to include keeping in close

touch with all national proposals directed toward bringing about changes in the form of medical practice in general.

Recently there has been considerable discussion of the future relationship which is to prevail between the American Orthopaedic Association, the parent organization, and the younger organizations now in the field. The trend of the general discussion on this subject indicates that the rôle of the American Orthopaedic Association should be a dual one: that of correlating the activities of these other organizations and, in addition, of continuing to produce new ideas for the advancement of our specialty. After all, these are not new activities. These have been the activities of the American Orthopaedic Association for the past fifty-three years. Certainly, if this Association is to live and to continue to exert the influence it is entitled to wield on the basis of past accomplishments, its membership must be a progressive, active, and productive one—anything else would mean stagnation and death. That the American Orthopaedic Association has from its inception been the clearinghouse for and the court of final appeal on the value of orthopaedic procedures, I am sure, will not be denied. It has maintained this position because it has been conservative in thought and slow to put its seal of approval on any procedure until it has been tested by time and proved by end results. Its rôle in this respect today is changed only in that it must modernize its machinery for doing the job. It is obvious that with the mass of material produced today, when orthopaedic surgeons are numbered by the hundreds, a different machinery for analysis and evaluation is necessary than was required when less than a hundred men composed the productive group. This new machinery has been provided by the formation of a Research Committee. This Committee is charged with the responsibility of selecting, by a poll of the orthopaedic surgeons of the country, important topics to be investigated, of selecting men to carry out such investigations, and of making each year a report on one of the topics being investigated. This Committee, availing itself of the nation-wide facilities which we hope will be placed at its disposal, should be able to bring up to date all known information on the subjects selected for study; and its report, after acceptance by the Association, should represent an authoritative expression of your opinion on that subject at that time. Such reports should be exceedingly valuable to all of us. It is very fitting that the first report of this Committee should have been one covering all of the orthopaedic problems at present under investigation. May I earnestly urge upon all of you the importance of cooperation with this Committee to the end that it may function effectively and that its reports shall reflect the widest possible distribution of opinion on any subject chosen for investigation. The scope of this Committee might well be enlarged along the lines suggested by its Chairman in his report. [See report in this *Journal*.]

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*The Journal* has been placed in a situation where it is receiving an increasing mass of material for publication, and it has responded to this demand in part by increasing its size. It has been suggested that the next logical step would be to issue *The Journal* monthly instead of quarterly. This would, however, add greatly to the cost of publication, and, before such a step could be taken, the Association must approve such action and provide for the additional cost. Also, it is quite doubtful whether sufficient material worthy of publication is being produced to warrant more frequent issues. The specialty of orthopaedic surgery may well be proud of the standards being maintained in its official journal; it would lose greatly in dignity if this standard were lowered by the publication of inferior material. It has also been suggested that the situation could result in the founding of a second journal devoted to orthopaedic surgery. This would, I believe, be an unfortunate move for two reasons: first, a desirable critical selection of the papers to be published is less possible in a journal with a looser and perhaps less discriminating editorial policy than in a journal controlled by a responsible organization through its editorial board; and, second, it is doubtful if there is a sufficient amount of suitable material to fill another journal, especially since many papers on orthopaedic subjects are being published in journals of a more general character.

There is a responsibility which rests upon the members of the American Orthopaedic Association that I doubt has been appreciated in its true importance. I refer to the obligation which rests upon each of us to provide satisfactory training to the extent of his ability for those who wish to enter the field of orthopaedic surgery. The American Board of Orthopaedic Surgery has set up certain standards which must be met by those who seek certification. If standards designed to maintain orthopaedic practice on a high level are to be set up, then it is obligatory upon the orthopaedic surgeons of this country to provide opportunity to acquire the training necessary to meet such standards. Members of the American Orthopaedic Association occupy the key positions of educational opportunity, and it is only when these opportunities are made available that the aspirant for orthopaedic certification can receive adequate training. It should be the aim of every member of this Association to so order his clinical set-up that it may become a part of a broad educational scheme, which will provide a well-integrated course of training for those who desire to take the Board examinations and eventually to enter the orthopaedic field. This does not imply merely providing sufficient credits to be accepted by the American Medical Association or the American College of Surgeons as a training ground. To do this means only that here and there we shall have established isolated opportunities for training which will be acceptable as credit for one, two, or three years, as the case may be. There must be, in addition, a willingness to coordinate these one-year and two-year training opportunities with others, so that an acceptable three-year period of training may be available for every applicant for Board certification

who is deserving of such training. It is possible that you may be called upon in the near future to cooperate with the American Board to this end.

It has been a time-honored custom to hold the Annual Meeting of the American Orthopaedic Association in the home city of its President. This has not always been geographically the most satisfactory place to hold the meeting, and at times the attendance has suffered in consequence. It has also been said that the time of the meeting, usually in May or June, conflicts with other meetings, such as those of the American Medical Association and the American Surgical Association, and brings it too close to the Academy meeting in January. To overcome these objections, it has been suggested that the Association change its policy of convening in the home city of the President and, instead, select a suitable and attractive resort and hold the meeting there at some time in the year, probably in the fall, when fewer meetings are being held. This arrangement would solve the geographical problem, avoid conflict with other conferences, make for a full attendance, and ensure an interesting and enjoyable meeting. Other societies comparable with our Association have done this successfully. This change in the time and place of meeting is one to which the Association might well give serious consideration.

I have stated that this Address was to be a report on the state of the Association, but it is impossible that it should be entirely so. One could not be closely associated for twenty years with the group of men who make up the American Orthopaedic Association without realizing that this Association is not merely an annual gathering together of individuals to read papers and to transact business. It is far more than this. It is and always has been a living force with an ideal as its soul. Carl Schurz has said: "Ideals are like the stars—we never reach them, but like the mariners on the sea, we chart our course by them." The ideal which has animated the American Orthopaedic Association is an imponderable force, which has greatly influenced the direction in which orthopaedic surgery has developed in this country for the past half century, and so is important. I shall, therefore, ask you to bear with me for a few moments while I attempt to put in words my conception of what this ideal is. This I have tried to do many times, but in vain, until I chanced to read Lin Yutang's philosophical discussion on "The Chinese Family Ideal". There I found expressed what I wished to say.

In a general way, Lin Yutang said: "The Chinese family ideal is backed by a view of life which I may call The Stream of Life Theory, which makes immortality almost visible and touchable. In place of the individualism and nationalism of the West, there is a family ideal in which man is not regarded as an individual but as a member of a family and an essential part of the great stream of family life. Every grandfather, seeing his grandchild going to school, feels that truly he is living over again in the life of the child. His life is nothing but a section of the great family stream of life, flowing on forever. He is important only so far as he contributes to the family honor and glory."

It occurs to me that in the American Orthopaedic Association we have somewhat of a counterpart of this stream-of-life ideal. The founders of this Association started a stream of life in orthopaedic surgery which has flowed on through fifty-three years and will flow on, we hope, for generations to come. These founders, as they grew older and saw new and younger members being added to the rolls, must have truly lived again in the achievements of these younger generations. They must have been filled with a sense of pride and satisfaction in seeing this new professional family which they had established growing in numbers and strength, as each new addition, through his contributions, added to its influence and importance. As the years have passed, I am sure that this stream-of-life ideal has continued to flow on in the American Orthopaedic Association, as each new generation has taken the place of an older one, which was happy indeed to hand over to vigorous youth, at the proper time, the responsibilities which it in its time had borne and to retire to the rôle of counselor and adviser.

With such a conception, it seems to me that one gets a lengthened outlook on the history of this organization and the manner in which it has been able to influence the development of the specialty of orthopaedic surgery through the five decades of its existence. Such a conception also enables us to envision what the influence of this Association may be on generations to come, for it gives it some of the qualities of immortality. The American Orthopaedic Association has had an honorable past and has faithfully discharged its obligations of directing the growth of a new specialty along the pathway of sincerity and service. As its stream of life flows on, it will, I am sure, continue to exert this same influence in the future, if each member will look upon himself not as an individual but as a branch of the orthopaedic family tree, growing upon its trunk and contributing by his very existence to its further growth and continuation.

Changing times bring changing problems, and we of the older generations view with some concern the problems for which you of the younger generations may be called upon to find the solutions. Changing times, however, do not change fundamental truths and fundamental standards. The honorable and unselfish precepts laid down by the founders of this Association for its guidance are just as sound and true today and will be tomorrow as they were yesterday. These precepts must be upheld and defended against all attempts at invasion, if this organization is to continue in the purpose in which it was conceived,—namely, that of maintaining the specialty of orthopaedic surgery on a plane of truth, progress, and service. These standards are not, I believe, so inflexible that the demands of changing conditions cannot be met within their framework, but, if adjustments and compromises are to be made without sacrificing principles, this Association must be strong and invulnerable. This, in turn, means that, as its stream of life flows on, it must live, as Lin Yutang puts it, “so as not to be a shame to its ancestors and to have sons of whom it need not be ashamed”.

# FRACTURES OF THE NECK OF THE FEMUR IN CHILDHOOD \*

BY JOHN C. WILSON, M.D., LOS ANGELES, CALIFORNIA

A review of the English literature on the subject of fractures of the neck of the femur in childhood leaves one with the impression that they respond to the regular forms of treatment as do those in adults. No great number of cases is tabulated, but in each instance the discussion concerns chiefly the various methods of treatment, with the conclusion that good functional recovery is the rule. A study of the author's series of cases gives rise to a somewhat different view.

Johansson, in 1927, published his observations on two patients, under twenty years of age, in whom aseptic necrosis of the femoral epiphysis followed fracture of the cervical neck. Zur Verth, in 1935, after gathering seven published cases and adding four of his own, stated that aseptic necrosis of the femoral head follows fracture of the cervical neck in children in the proportion of four to ten. Nielsen, in 1938, reported three cases of Legg-Calvé-Perthes disease following fracture of the neck of the femur. The changes are explained by a vasomotor disturbance of the vessels supplying the femoral head.

The incidence of this fracture is not great. There were two fractures of the neck of the femur in children among 600 fractures of the upper end of the femur treated at the Los Angeles General Hospital in the past ten years. Since August 1930, the author has seen ten such fractures in children, and the following study of the end results in these cases is presented to point out the dangers which follow this injury and to suggest methods of treatment.

## *Sex*

As would be expected, seven of the patients were males and three were females.

## *Age*

Four were in the first decade of life and six were in the second.

## *Etiology*

In 1935 a motion picture appeared which glorified the athletic youth by portraying a young man springing from one branch of a tree to another with the greatest of ease. Stimulated by this glamorous hero, two young men, who were less dextrous in the tree tops, sustained a fracture of the neck of the left femur. Seven suffered other forms of severe trauma, caused by falling forty feet from a cliff, falling from a horse, and being in an automobile accident. In only one case was the trauma slight. In

\* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Boston, Massachusetts, on January 25, 1940.

TABLE I  
RÉSUMÉ OF TEN CASES OF FRACTURE OF THE FEMORAL NECK IN CHILDREN

Case No.	Sex	Age (Years)	Date of Injury	Side	Treatment	Complications	End Result
1	Female	6	Aug. 1930	Right	Cast and crutches Bone-grafting operation	Non-union	Patient died on June 25, 1931, from shock following bone-grafting operation.
2	Female	9	Feb. 1931	Left	Cast for 5 months	Fragments slipped	Feb. 1934: 3 centimeters of shortening; 45 degrees of flexion deformity; Growth changes in head; Limp.
3	Male	11	Jan. 24, 1932	Left	Cast Cast and pin transfixion through shaft of femur	Fragments slipped in first cast	Nov. 29, 1939: 2 centimeters of shortening; 3 centimeters of atrophy of thigh; 25 degrees of limitation of flexion and external rotation; 20 degrees of limitation of adduction and abduction; 10 degrees of limitation of internal rotation and extension; Limp.
4	Male	12	Mar. 26, 1934	Right	Cast for 120 days July 15, 1938: Subtrochanteric osteotomy to correct flexion-adduction deformity of hip	Phlebitis	Dec. 8, 1939: 1 centimeter of shortening; 9 centimeters of atrophy of thigh; 3 centimeters of atrophy of calf; 25 degrees of limitation of flexion; 15 degrees of limitation of extension; Slight limp.

5	Male	12	July 14, 1935	Left	Traction for 35 days Cast for 60 days Crutches for 9 months	None	Circulatory changes in head of femur; Slight limitation of internal rotation in flexion; Good function.
6	Male	9	July 21, 1935	Left	Cast Nov. 20, 1935; Bone-grafting operation Dec. 8, 1936; Osteotomy to correct coxa vara	Sept. 12, 1935; Acute appendicitis	Apr. 1938; Stiff hip, 32 months after injury.
7	Male	13	Aug. 1935	Left	Manipulation (osteopathic) for 5 months Cast for 90 days	None	Jan. 5, 1940; 3 centimeters of shortening; 20 degrees of limitation of adduction No rotation or extension Lump
8	Male	15	Dec. 12, 1937	Left	Traction Manipulation Feb. 10, 1938; Nailing Feb. 27, 1938; Reconstruction operation	Feb. 23, 1938; Nail broke Apr. 18, 1938 Wound infected	Nov. 1939; Hip stiff, with pain and swelling Total disability.
9	Female	12	July 15, 1938	Right	Oblique subtrochanteric oste- otomy and cast	Poliomyelitis Paralytic dislocation	Good function.
10	Male	8	Nov. 3, 1939	Right	Cast		Undetermined—too recent.

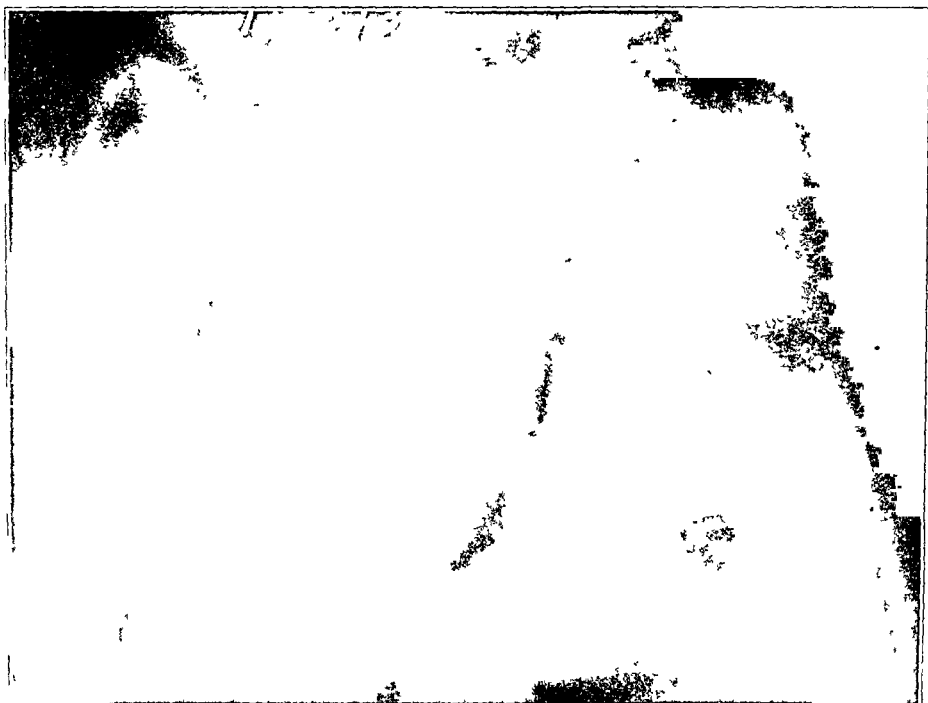


FIG. 1-A

Case 3. January 24, 1932. Fracture of the neck of the left femur in a boy, eleven years of age, who fell fifty feet from a cliff. The fracture was reduced and the hip placed in a Whitman cast. The position could not be maintained without transfixion of the femoral shaft.



FIG. 1-B

Case 3 April 12, 1932, three months after injury. There is no evidence of repair, and the head is dense.



FIG. 1-C

Case 3. September 8, 1932, eight months after injury. The fracture of the neck is healing. The circulation of the head is markedly disturbed.



FIG. 1-D

Case 3. September 15, 1935, three years and eight months after injury. The fracture is healed; the head is small, showing evidence of necrosis and revascularization.

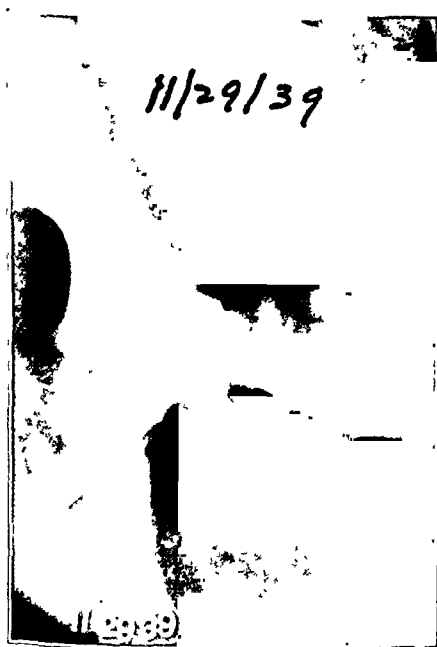


FIG. 1-E



FIG. 1-F

Case 3. Lateral and anteroposterior views of left femur on November 29, 1939, nearly eight years after injury, reveal a distorted head and neck. The leg is 2 centimeters short, and all movements of the hip are restricted.



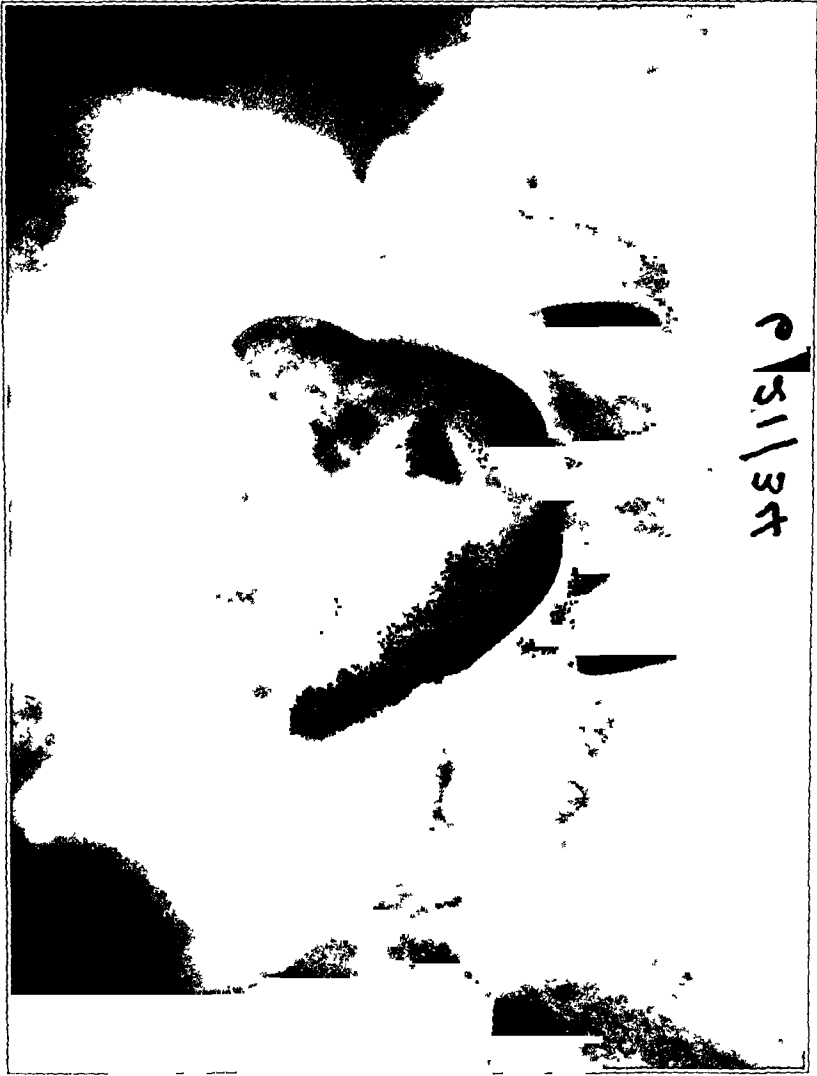


Fig. 2-B

Case 4. June 21, 1934, three months after injury. The fracture is healed in fairly good position, although the head is slightly rotated

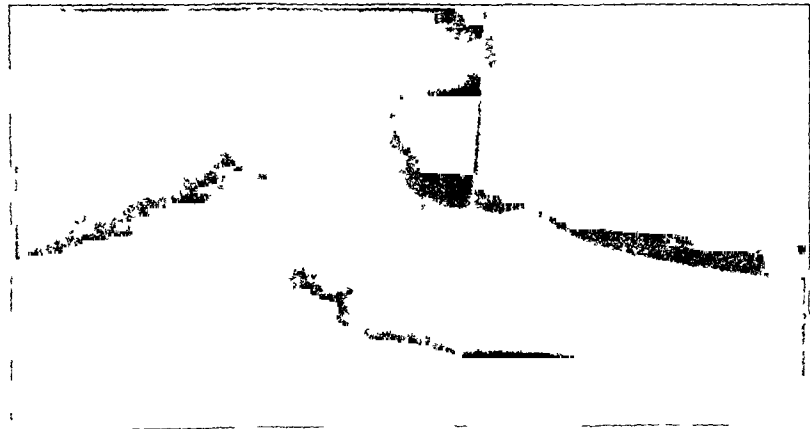


Fig 2-A

Case 1. A boy, aged twelve, fell eight feet from a tree, sustaining a fracture of the neck of the right femur. The fracture was reduced and fixed with a Whitman-type plaster cast.



FIG. 2-C

Case 4. September 17, 1935, eighteen months after injury. Changes in the head and neck are taking place.



FIG. 2-D

Case 4. February 19, 1936, twenty-three months after injury. The growth disturbance is more evident.



FIG. 2-E

Case 4. August 7, 1936, five months later than Fig. 2-D. The irregularity in the head and neck is more pronounced.



FIG. 2-F

Case 4. April 5, 1937, eight months later than Fig. 2-E.



FIG. 2-II

Case 1. October 11, 1935, four and one-half years after injury. On July 13, 1938, a subtrochanteric flexion deformity of the hip. The boy lumped badly at that time and had 7.5 centimeters of apparent shortening.

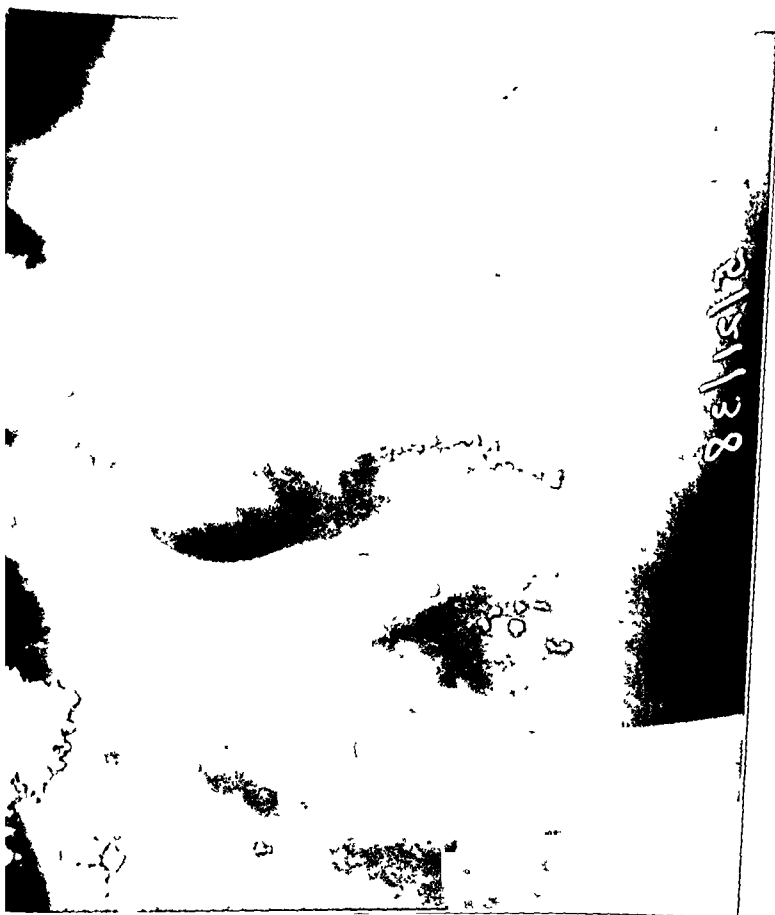


FIG. 2-G

Case 4. May 21, 1938, four years and two months after the injury. The head and neck are markedly distorted.

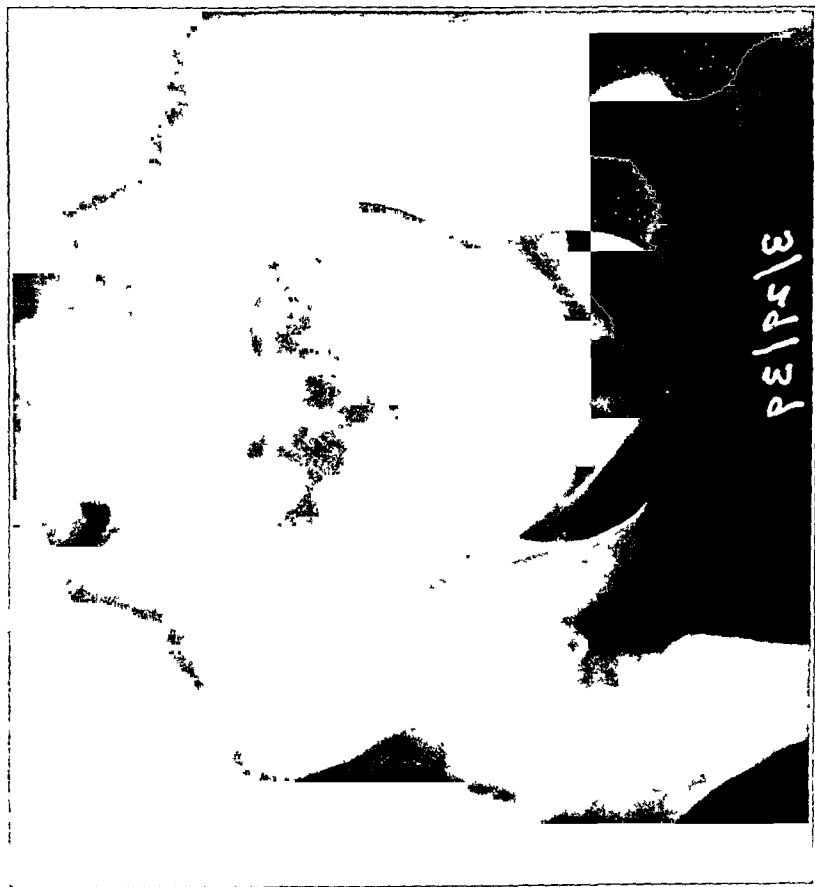


FIG. 2-I

Case 1. March 29, 1939, five years after the accident. These roentgenograms show a badly deformed but revascularized head and neck of the femur. The leg is 1 centimeter short. The thigh and calf are atrophied. Flexion is limited 25 per cent. and extension, 15 per cent. Impossible as it may seem, other movements of the hip joint are free.



FIG. 2-J

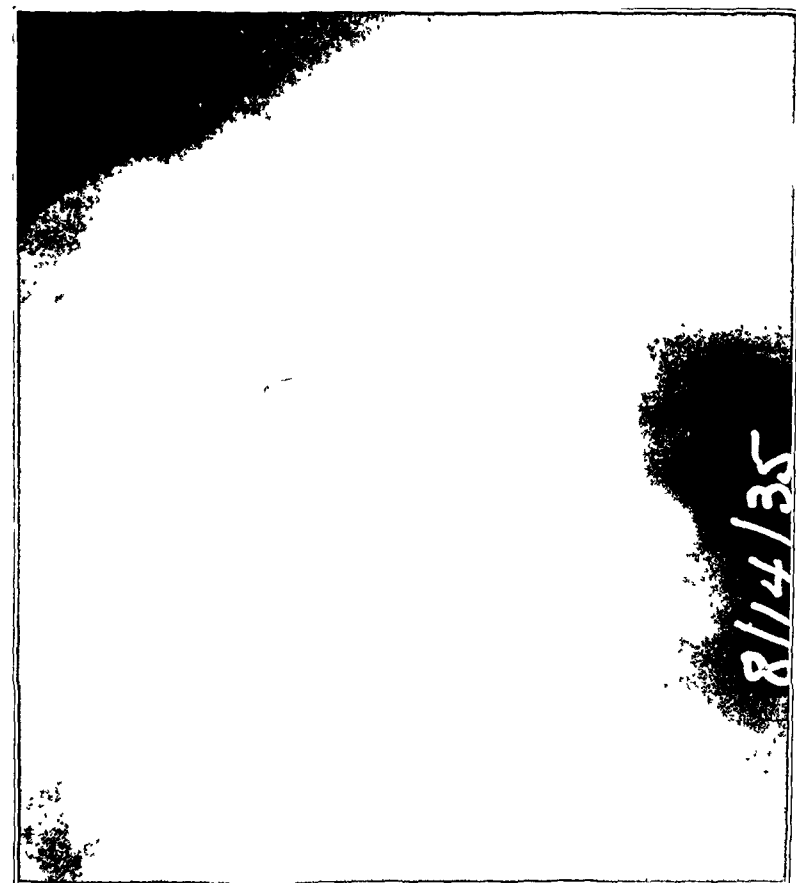


Fig. 3-A

Case 5. August 14, 1935. Fracture at the base of the neck of the left femur with some disturbance of the trochanteric epiphysis. This fracture was complicated by a fracture of both bones of the same leg, just below the knee joint.



Fig. 3-B

Case 5. September 4, 1935, after twenty days of fixation in a plaster spica. The position is satisfactory, and repair is in evidence.

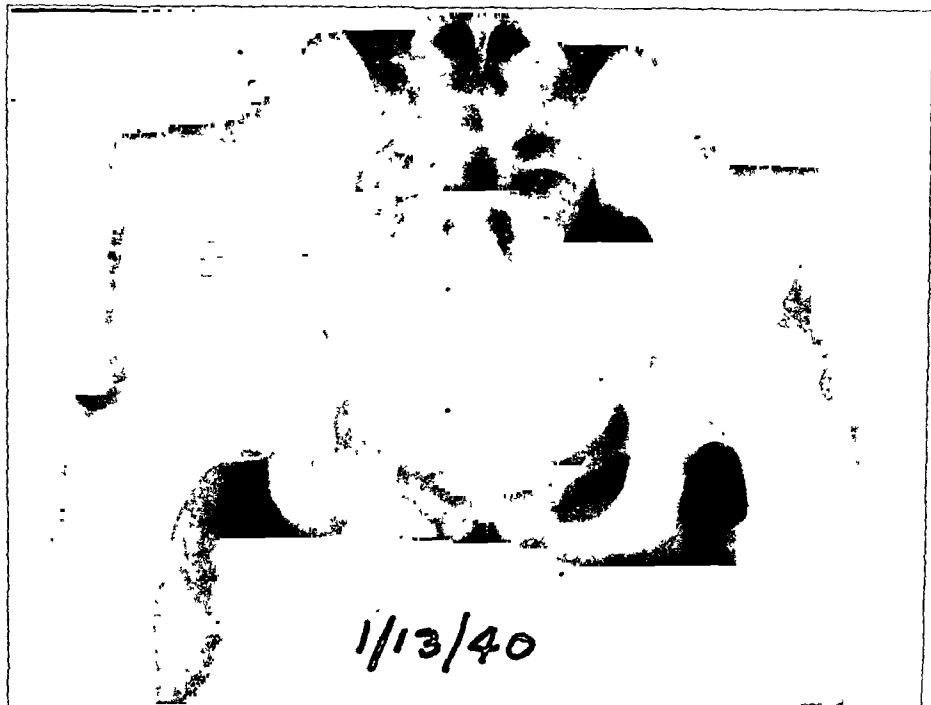


FIG. 3-C

Case 5. January 13, 1940, four and one-half years after injury. The fracture is well healed. The head shows evidence of disturbed circulation, and the neck is somewhat shorter and wider than that of the opposite femur.

At the present time this boy has no shortening or limp. The left thigh is 4 centimeters less in circumference than the right. Internal rotation of the thigh flexed to a right angle is slightly limited. This is a good functional result.



FIG. 4-A



FIG. 4-B

Fig 4-A: Case 8. December 13, 1937. Fracture of the neck of the left femur in a boy, fifteen years of age.

Fig 4-B: Case 8. February 10, 1938. After four weeks of traction, the head was fixed with a Smith-Petersen nail. The head of the femur is now beginning to show evidence of a circulatory disturbance.

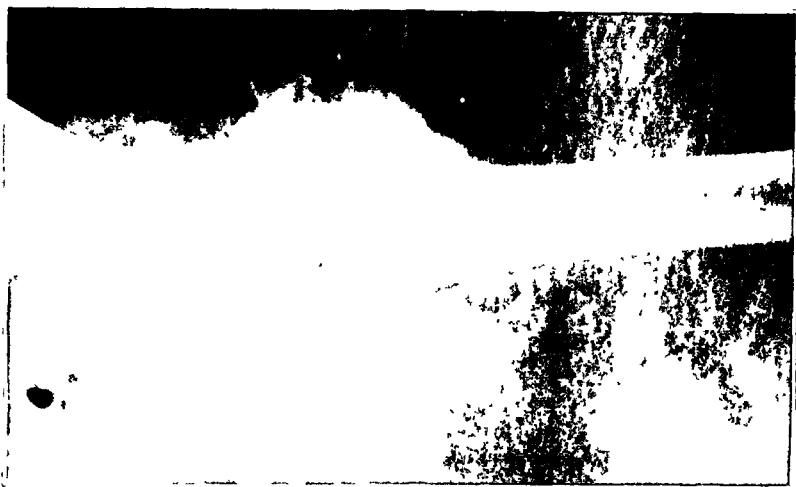


FIG. 4-E

Case 8. June 1, 1939. Two months after injury a reconstruction operation had been done. This film, fifteen months after this last operation, shows an avascular head, and the fracture line is still visible. The result is a stiff and painful hip.



FIG. 4-D

Case 8. February 23, 1939, five months later than Fig. 4-C. The head and nail both show evidence of disintegration.

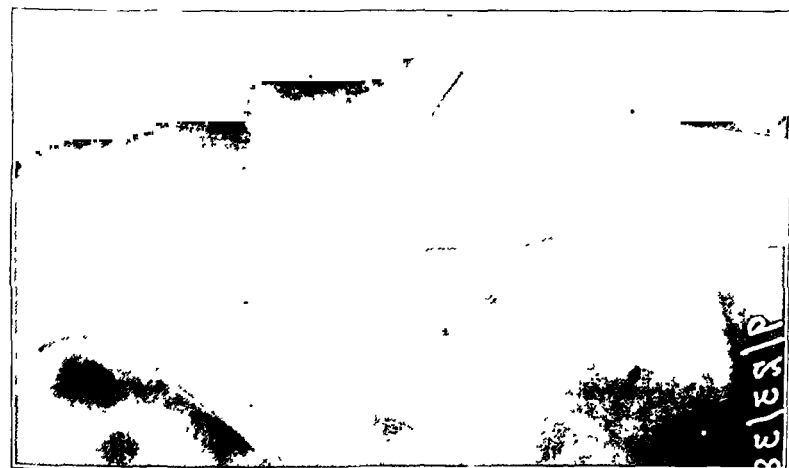


FIG. 4-C

Case 8. September 23, 1938, seven months later than Fig. 4-B. The reduction is not good, and the femoral head is quite dense.



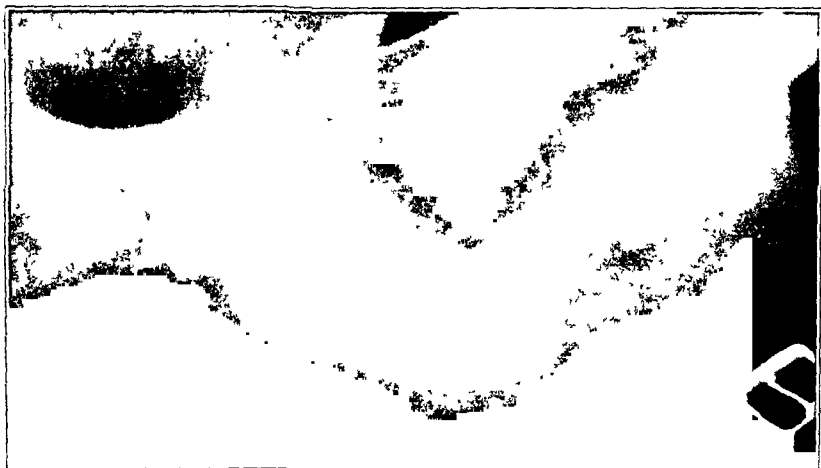


FIG. 5-C

Case 9. December 22, 1938. This film, taken with the leg in complete adduction in an attempt to dislocate the hip, shows to better advantage the osteotomy and healed fracture. No evidence of growth disturbance is seen in the femoral head. Further observation is warranted.



FIG. 5-B

Case 9. August 10, 1938. The leg was first placed in traction, and this film shows the beginning coxa vara deformity.



FIG. 5-A

Case 9. July 15, 1938. Fracture through the neck of the right femur, with some rotation of the head, in a girl, aged twelve years, who suffered from the residual effects of infantile paralysis. She fell while walking across the floor.

this case the femoral neck in a paralyzed extremity was fractured by a fall while the patient was walking across the floor.

### *Pathology*

Six of the fractures occurred in the left femur and four in the right. In no instance was the fracture located near the head. They all occurred centrally or near the base of the neck.

### *Treatment*

Eight of the patients were treated by the so-called Whitman cast. In seven instances satisfactory reduction was not maintained. The slipping of the fragments was discovered in one case early enough to allow correction and transfixion of the shaft of the femur by a pin, which was incorporated in the cast.

In one patient the femur was nailed, and, through no fault of the procedure, the case terminated unfortunately. An oblique subtrochanteric osteotomy was done in one case in which the hip dislocated, because of muscle weakness following infantile paralysis. It was hoped that the osteotomy would stabilize the hip and facilitate healing of the fracture, both of which were accomplished.

### *Mortality*

One patient died as a result of treatment. The child entered the Hospital ten months following the injury, with a non-union of the fracture after treatment by the cast method. An intramedullary bone-grafting operation was done, and the patient died from shock the same day.

### *Results*

One of the nine remaining patients was injured only two months previous to this report, so that the outcome cannot be anticipated. Of the remaining eight patients, two have good functional results.

### COMMENT

Many interesting points arise in the survey of these patients. The circulation of the femoral head has not been worked out as yet to the satisfaction of all investigators. Cella, after a series of experiments on animals, came to the conclusion that, while the vessels of the ligamentum teres play a part in the development of the femoral head, they are not essential, and their interruption does not alter its conformation. Nielsen, on the other hand, thinks that disturbance of the nerve supply to the vessels is the prime factor. Irrespective of cause, gross disturbance of joint mechanics usually follows. Such joints must show premature evidence of wear and tear, which is commonly called degenerative arthritis.

### CONCLUSIONS

A study of this series of patients forces us to conclude that fractures of the neck of the femur in childhood are serious injuries. Maintenance of

reduction in the Whitman cast is difficult. Perhaps a nail would be more effective, but, again, will it damage the epiphyseal plate? One should be alert to the fact that growth changes are to be expected. The disturbances in growth in this series of patients do not conform to the classic picture of Legg-Calvé-Perthes disease. Oblique subtrochanteric osteotomy is helpful in bringing a limited arc of motion into useful planes.

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# CONGENITAL FLAT-FOOT

## A NEW SURGICAL APPROACH \*

BY J. WARREN WHITE, M.D., GREENVILLE, SOUTH CAROLINA

*From the Shriners' Hospital for Crippled Children, Greenville*

The purpose of this paper is to call attention to a surgical technique in the treatment of congenital flat-foot, too severe for conservative therapy, which depends on a principle different from those being generally advocated at the present time. By congenital flat-foot the author means the severely pronated and abducted long, narrow foot, lacking to a large extent the plantar concavity of a normal arch. The deformity is invariably bilateral, but is frequently much worse on one side. Symptoms ordinarily develop during the early adolescent period of rapid growth, when skeletal growth exceeds muscle development and where there usually has already existed some muscle atony.

Beginning years ago in doing Hoke flat-foot stabilizations<sup>4</sup> in poliomyelitis cases, the author gradually replaced less and less of the excised astragalar head and finally noted that his results were better in those cases where nothing was replaced, and the inner border of the foot was shortened accordingly. This principle has been employed for some time by shoemakers in designing corrective shoes, as seen in the "swung-in" or "swung-out" lasts. In the writer's experience, these shoe modifications have been most useful in what might be termed the convalescent treatment of club-foot and the conservative treatment of the milder forms of flat-foot.

Dwight, over thirty years ago, in his classic book on "Variations of the Bones of the Hands and Feet", in discussing the shape of the astragalus stated: "It may be long and narrow or short and broad; the neck may diverge much or little from the axis of the body, the shape and inclination of the head are very uncertain. It can hardly be doubted that these variations must have an important influence on the shape of the foot and on its movements. But the genius who should work this out has not yet appeared." The author makes no claim to being a genius, but it has long been apparent to him that in a case such as that shown in Figure 1-A, regardless of any muscle impairment or imbalance, it would be difficult to swing the navicular, with the part of the foot distal to it, around into its normal relation to the body of the astragalus without very materially shortening its neck or without generously removing the astragalonavicular joint as an alternative.

Just as the writer feels that the excessive length of the astragalar neck explains a certain type of flat-foot, so does he think it possible that

\* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons Boston, Massachusetts, on January 24, 1940.

reduction in the Whitman cast is difficult. Perhaps a nail would be more effective, but, again, will it damage the epiphyseal plate? One should be alert to the fact that growth changes are to be expected. The disturbances in growth in this series of patients do not conform to the classic picture of Legg-Calvé-Perthes disease. Oblique subtrochanteric osteotomy is helpful in bringing a limited arc of motion into useful planes.

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the underdevelopment of the inner border of the foot can explain club-foot. In several instances he has felt certain that complete correction or overcorrection, as it is inaccurately called, has been accomplished, and yet, in a few years, the varus deformity has recurred in spite of roentgenographic proof of the correction of the varus position of the navicular. It is admitted that tendencies toward shallow acetabula, club feet, supernumerary digits, and other deformities are inherited. Why is it not probable that long astragalar necks are acquired in the same way?

Most of the operations devised for the correction of these relaxed flat feet depend for their success on the production of an arthrodesis to establish a bone arch.<sup>6, 7</sup> If the arthrodesis fails, the correction is not maintained; even if it does not fail, the shape of the arch in the course of years will succumb to the forces that change the shape of all bones according to the stresses and strains applied to them. By the deliberate shortening of the inner border of the foot and the lengthening of the outer border, the author has proved to his own satisfaction that the correction is much more positive and lasting than is that effected by the simple arthrodeses, regardless of the number of joints included. The "buckling"—for such it really is—of the inside of the foot results in a correction, at least in the writer's hands, that is much surer and more permanent than is secured by the other procedures.

There is no denying that the various arthrodesing operations, combined usually with some sort of transarticular bone-grafting, accomplish a certain amount of shortening, but that valuable part of the procedure is not stressed. Miller, in describing his technique, does make mention of the fact that: "In cases of long standing the head and neck of the astragalus have grown appreciably longer and the point of the scaphoid is hypertrophied on its inner aspect. In such a case (though such cases are not so frequently seen) one can shorten the neck of the astragalus by taking out a section with the osteotome." Aside from this quotation, the author has been unable to find, in a survey of the leading articles on the surgical correction of flat-foot, any publication that calls particular attention to the discrepancy in the length of the inner and outer borders.

To be sure, there are many cases of generalized muscle atony that result in severe pronation, but the writer is certain that there frequently exists this fundamental anatomical defect in the shape of the bones that can be responsible for foot imbalance and which, when corrected, allows the tibial group of muscles to function in a more normal way.

Attention may be called to the fact that shortening the inner border of the foot very well corrects the valgus of the forefoot, but it does not take care of the calcaneal valgus. The explanation of this lies in the fact that, in addition to the mechanical disadvantage which is imposed on the tibial muscle group by this long inner border, regardless of their actual tone or strength, the elongation pushes the forefoot into a valgus position and must necessarily react on the cuboid and thence on the calcaneum to cause a valgus there.

The operation advocated in this paper has been evolved gradually and consists in the removal of a wedge of bone from the astragalar neck. Because of the length of the neck, this is relatively easily done and can usually be accomplished without encroaching upon the anterior sub-astragalar articular surface.

Through a two-inch longitudinal medial incision, centered over the astragalar neck, a transverse osteotomy is done completely across that bone where the body and neck join, — that is, just anterior to the superior articular surface of the astragalus above and the anterior articulating surface of the subastragalar joint below. It is suggested that an articulated skeleton of a foot be examined before the operation is attempted, so that the relationships may be fully appreciated. It will be seen immediately how well the architecture of the astragalus and the calcaneum lends itself to this remodeling procedure and how accurately the wedge removed from the medial aspect of the astragalus fits the opening made by the osteotomy on the lateral surface of the calcaneum. The tendon of the tibialis posterior is usually encountered and can be easily retracted downward.

Another transverse osteotomy is then done, usually three-eighths to one-half an inch anterior and parallel on the surface to the first, but directed posteriorly, so as to intersect the first osteotomy about in the middle of the foot from one-quarter to one-half an inch lateral to the medial extremity of the first osteotomy. This sounds rather complicated, but the reason for it can be seen in the accompanying diagram (Fig. 2). The purpose of the operation is to shorten the inner and to lengthen the outer border of the foot. To ensure proper closure of the wedge-shaped opening made by the removal of the cuneiform fragment produced by the two osteotomies, the forefoot and anterior tarsus are swung medially in a varus position, the center of motion being a vertical axis coinciding with the intersection of the two osteotomies.

Care must be taken to clean the angle clear to its depth, so that complete closure may occur after the calcaneum is transversely osteotomized about a quarter of an inch posterior to the calcaneocuboid joint and just about in the same plane but lateral to and below the site of the first astragalar osteotomy on the medial side of the foot. This osteotomy passes through the bone on the medial aspect just anterior to the point where the sustentaculum tali projects medially beneath the astragalus. This transverse calcaneal osteotomy allows an open wedge to appear when the astragalar wedge is closed at the time the forefoot is swung in. This opening is then filled accurately with the bone wedge removed from the astragalus, trimming only being necessary laterally to make it flush with the surface of the calcaneum.

If more correction is desired because of the inaccessibility of the astragalar neck, the overhanging navicular tuberosity may be chiseled off, and a wedge, ranging up to twice the width at the base, may be excised. If this happens to include the proximal insertion of the tendon

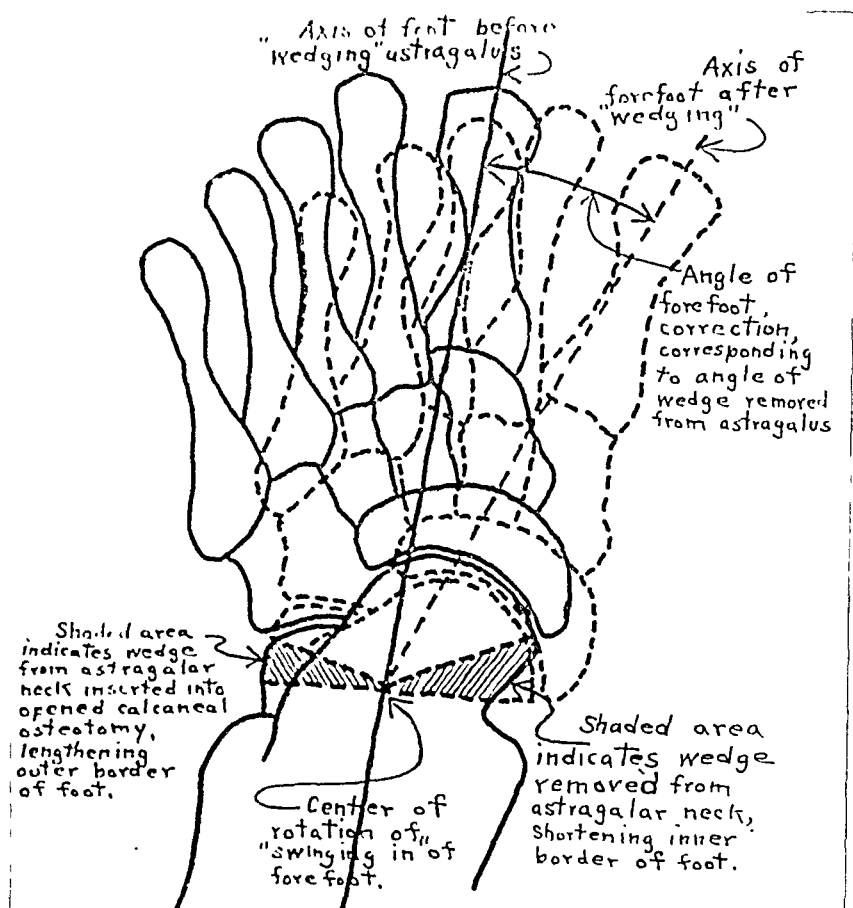


FIG. 2

Tracing of roentgenogram of a severely pronated foot suitable for surgical correction. Dotted outline shows position of "forefoot" after closure of wedge removed from astragalar neck, which is inserted into the opening made by the calcaneal osteotomy. The transverse osteotomy must be carried all the way across the astragalar neck, and the anterior one to complete the wedge must be directed toward the "center" of the foot at this point ("center of rotation" in the tracing).

of the tibialis posterior, it makes no difference, as this tendon attaches itself again to the exposed cancellous bone. Usually, however, this insertion is well underneath and is not disturbed.

Both wounds are closed in layers, and a plaster-of-Paris cast is applied from just below the knee to the ends of the toes with the forefoot in as much varus as can be easily obtained and in slight equinus.

If there is any possibility that the heel cord may be short, it should be lengthened as a preliminary step. The author has found it necessary to do this in about half the cases.

The plaster is allowed to remain on two months, and some type of "swung-in" shoe, with a one-eighth-inch extra wedge on the inside edge of the heel, is worn for the first six months. Exercises directed toward



mobilizing the foot and strengthening the tibial group of muscles are started immediately after the removal of the cast.

If this procedure is followed out the important shock-absorbing mediotarsal joint is preserved, which results in a more normal foot. More normal growth will occur as the osteogenic cells immediately behind the articular cartilage are left undisturbed in both bones. Incidentally, the author feels sure that the distressing varus which occasionally develops in feet stabilized according to the Hoke technique results from the cessation of growth at the site of the astragalonavicular arthrodesis in those cases where care has not been taken to arthrodesse the calcaneocuboid joint, which would arrest growth there as well.

In the sixth edition of Whitman's "Orthopedic Surgery", Perthes' operation for this condition is described, in which a section of bone is removed from the navicular and the anterior portion of the calcaneum is lengthened. The author has tried this a few times, but he always feels that he cannot get enough correction without removing practically the entire bone. The illustration given in Whitman's textbook is most misleading, as it shows in the lateral diagram an astragalus without a head; the navicular really occupies the place of the head and neck of the astragalus. Therefore, as it is erroneously pictured, Perthes' operation practically amounts to the technique which the writer is advocating. The author feels also that the fault is not in the navicular but in the astragalar neck, and so why not make the correction there where there is adequate room and where the valgus really begins? In addition to the structural correction of the forefoot valgus the shortening of the astragalar neck gives to the tibialis posterior, the first insertion of which is to the under side of the tuberosity of the navicular, a more direct pull and adds a definite amount to its value as an "arch supporter".

The principal error which the author has made in carrying out the technique being discussed is that he has not removed sufficient bone for adequate correction, and, if one uses only the navicular, the temptation to do an inadequate operation is all the greater.

The common occurrence of enlarged navicular tuberosities, whether or not the prehallux or the accessory navicular is present, the author believes is more than a coincidence and is a strong argument in favor of the condition's being primarily a bone defect rather than a muscle imbalance. To be sure, the muscle imbalance is present, but the writer feels that, in the particular type of case under discussion, if the bone deformity is corrected proximal to the insertion of the tibialis posterior, as has been stated, the muscle balance can be more easily restored by training. In these cases the author has frequently, but not invariably, excised the overhanging portion of the navicular, including the accessory bone, if present. Various authors, particularly Kidner, have called attention to the value of simply removing the surplus navicular material on the medial aspect in the correction of a pronated foot, where the forefoot is held in valgus because of its infringing on the medial malleolus.

Only eighteen of these flat-foot operations have been done according to the technique described, but many more with a somewhat similar technique have been performed where the astragalonavicular joint has been sacrificed. In all but four of these, it is significant to note that the pronounced overhanging of the tuberosity of the navicular has been present, associated in nine instances with a supplementary or "accessory" navicular. Dwight gives the frequency of this supernumerary bone as 10 per cent.; Pfitzner, as 11 to 12 per cent.; and Geist, in his investigation of 100 normal individuals, as 14 per cent.

The first patient in this series was operated upon four years ago, and all but six have been operated upon over a year; the last four had bilateral deformity and have only recently been operated upon. In seven patients the operation was done bilaterally, although considerable pronation was noted in the unoperated feet of the other four patients.

Objectively, a satisfactory amount of correction was noted with one exception, in which case a severe amount of deformity was recorded at the start. Both operations in the bilateral cases were done at the same "sitting" in all but one instance, when an insufficient amount of deformity was considered to be present on one side. In this case the second operation was done subsequently at the patient's request.

No unsatisfactory results were reported, with the one exception noted, and the chief complaint was the persistence of discomfort of a varying extent, referable to the medial half of the mediotarsal joint, and gradually becoming less.

The condition under discussion should, the author feels, be cared for conservatively and the suggested operation should not be done before the early "teens", as the deformity frequently is not well established prior to that age. This fact strongly indicates that the deformity is the result of a growth disturbance of some kind,—possibly the reverse mechanism of that causing club-foot. Also, as in routine foot stabilizations, the operation can be done much more satisfactorily if there is present a minimum amount of pre-osseous cartilage.

The advantages of this operation may be briefly summarized as follows:

1. The correction of the valgus deformity is accomplished without disturbing to any serious extent any articulation.
2. Subsequent growth is impaired to a minimum extent, as the osteotomies are well away from the growing articular surfaces.
3. The simplicity of the procedure, after it has been thoroughly understood, permits its being easily performed even by the less-experienced surgeon.
4. The relatively painless and uncomplicated convalescence favorably impresses the patient.

In conclusion, the author wishes to state that he is emphasizing in this paper the mechanical advantage of "warping up" or "buckling" the inner and under border of the foot by a safe, natural surgical approach

in the more radical treatment of those cases of what is commonly known as congenital flat-foot.

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# ARTHRODESIS OF THE FIRST METATARSOPHALANGEAL JOINT

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It is necessary at times to consider arthrodesis of the first metatarsophalangeal joint. When this is contemplated, two main problems arise:

1. What is the optimum position for fusion?
2. How can this position best be obtained?

## OPTIMUM POSITION

When one seeks the optimum position for fusion of the great toe, it is important to know whether or not the toe should be placed at an angle which will aid in the "take-off" at the end of the walking phase.

It is felt by some surgeons that the great toe plays a definite rôle in the formation of a smooth gait, especially during the take-off at the end of the walking phase. They feel that the removal of this toe leads to a certain hesitancy in motion. On the other hand, it has been the experience of this Clinic that the gait is essentially normal after amputation of the great toe, that it is synchronous, and that the loss of the toe does not trouble the patient. It has also been the experience in this Hospital that in many cases of claw-foot and severe hallux valgus, in which the great toe never touches the floor, the gait is not affected materially by the loss of the propulsive action which this toe gives to the foot.

It is believed, therefore, that, when arthrodesis of the first metatarsophalangeal joint is performed, a position of the great toe should be chosen which does not subject it to much strain at the end of the take-off during the normal walking phase. Were the toe to be fused in such a position that it received a full-weight thrust, it is conceivable that enough strain would be placed on the distal phalanx through the interphalangeal joint to produce a traumatic osteo-arthritis. Actually, in our series of fourteen cases, one patient had definite pain at this joint, due to this cause. Another patient showed a hypermobility of the distal joint with 30 degrees of extension beyond normal limits.

A satisfactory position for the arthrodesis of the first metatarsophalangeal joint was found in two patients in whom a spontaneous fusion of unknown cause had developed. The position of one of these toes, which was believed to be the result of a congenital fusion, was at 25 degrees of dorsal extension on the metatarsal shaft. The angle which it formed with the ground is not known, since a roentgenogram with the patient standing was not taken. No lateral roentgenogram is available of the other spontaneous fusion, so that it is not known at what position it was



these patients is considered satisfactory because they have no symptoms referable to the great toes.

#### METHOD OF OBTAINING OPTIMUM POSITION

If the tenet is accepted that the fused great toe should be placed in a position which will not produce undue strain during the walking phase, then the optimum position will vary in men and in women. This is due to the difference in the height of the heel of the shoes in the two sexes. A man's shoe has a heel varying in height from one to one and one-quarter inches. A reasonably fashionable woman's shoe has a heel height which varies from two to two and one-half inches. This variation in the heel height causes the first metatarsal shaft to form different angles with the planes of the ground. In a man the angle that the first metatarsal shaft forms with the ground may be 15 degrees, while in a woman it may measure 35 degrees.

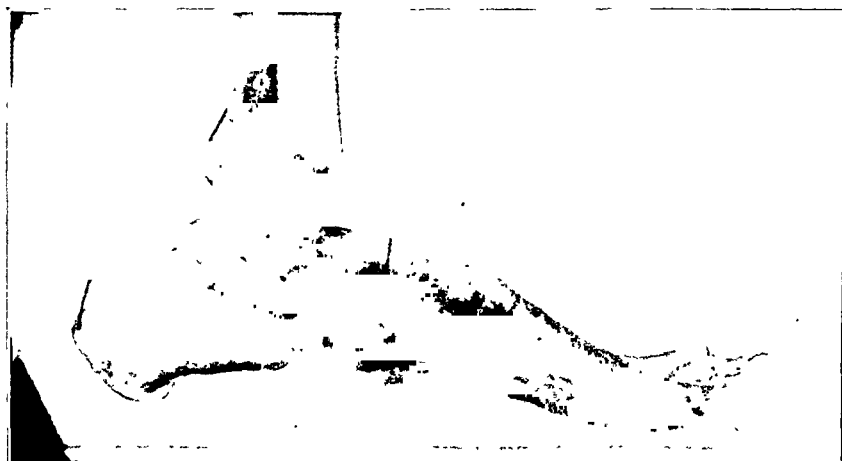


FIG. 2

Same case as in Fig. 1-A. Postoperative view of foot with the patient standing and without the shoe. Note position of great toe.

From a roentgenographic study of feet in shoes, we have estimated that the great toe should be fused in a position of at least 15 degrees of dorsal extension from the plane of the ground in order to prevent undue strain on the distal joint at the end of the walking phase. In the case of a man, if the preoperative lateral roentgenogram, taken with the patient standing and with shoes on, shows that the first-metatarsal shaft forms an angle of 15 degrees with the ground, then the optimum position for arthrodesis for that particular individual is 30 degrees (15 degrees plus 15 degrees) on the first-metatarsal shaft. Similarly, in the case of a woman, if the preoperative lateral roentgenogram, taken with the patient standing and with shoes on, shows that the metatarsal shaft forms an angle of 35 degrees with the ground, then the optimum position for fusion is 50 degrees (35 degrees plus 15 degrees) on the first-metatarsal shaft.

This position will be comfortable when the patient wears the usual type of shoe. There is no rubbing of the tip of the toe against the box of the shoe. No patient in our series had symptoms caused by too much extension of the toe on the metatarsal shaft, while one patient did have pain from not enough extension.

Figures 1-A and 2 show the method of obtaining roentgenograms with the patient standing with and without the shoe. Figure 1-B illustrates the method of measurement of the angle formed with the ground. This particular patient was a woman whose toe was fused at an angle of 70 degrees. There were no symptoms following the fusion.

We advocate this simple method of computation of the optimum angle, because arthrodesis of this joint usually occurs in the same position at which the toe is placed at operation.

#### INDICATIONS FOR ARTHRODESIS

In this Hospital arthrodesis of the first metatarsophalangeal joint has been performed for the following conditions:

1. Tuberculosis.
2. Poliomyelitis, in which a marked hallux flexus with accompanying first-metatarsal "cock-up" has been present.
3. Hallux valgus, if the great toe has been dislocated, or if pain has been marked following transverse resection of the first-metatarsal head.
4. Hallux rigidus.

#### TECHNIQUE

A tourniquet is used to provide a bloodless field, and the first metatarsophalangeal joint is exposed by a dorsal longitudinal incision. The articular cartilage is removed; the raw bone surfaces are fish-scaled; and care is taken to obtain good bone contact of the fragments at the estimated optimum position. A bone key, reinforced with bone chips, is inlaid across the joint. In cases of tuberculosis all diseased areas are curetted, and the defect is packed with bone chips taken from the metatarsal shaft. The wound is closed, and a short plaster boot is applied.

Lateral and anteroposterior roentgenograms are taken after operation to check optimum position, alignment, and contact. If the position is not correct, the toe is wedged on the tenth day. The cast is then left on for eight weeks. If the fusion is considered solid, an arch support is supplied, and the patient is allowed to walk.

#### CONCLUSIONS

1. The propulsive action of the great toe is not essential for normal gait.
2. From a study of fourteen cases in which the first metatarsophalangeal joint was fused, the optimum position for arthrodesis of the great toe has been determined as not less than 15 degrees from the plane of the ground with the shoes on.

## FRACTURES OF THE TIBIAL PLATEAU \*

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Conservative treatment of fractures involving the tibial plateau often does not yield a satisfactory result. Genu valgum, lateral instability, limited motion, and painful knees with chronic synovitis represent the types of disability in many knees so treated.

It is the purpose of this paper to show that the extent of the injury cannot always be determined by roentgenographic or clinical examination, that often the meniscus is irreparably damaged, that more often than not the bone and articular cartilage are comminuted to the extent that extra-articular manipulation will not suffice for reduction, and that, therefore, intra-articular exposure is necessary.

It is generally conceded that these fractures are caused by an external force, this force being an abduction of the tibia on the femur, the result of a blow from the side by a forceful agent, usually an automobile; hence the name "bumper" or "fender" fracture, so well described by Cotton and Berg in 1929. When the knee joint is fully extended, the condyles of the femur are fitted snugly into the articular facets of the tibial plateau, and the ligaments, tendons, and fasciae surrounding it serve as a protective mechanism for weight-bearing and stability. It is obvious that this mechanism must give way before an overwhelming force. It is equally obvious that if the protective ligaments, muscles, and fasciae yield from a sudden overpowering stress, bone injury will not occur often, inasmuch as the resultant instability of the knee as a whole prevents the action of the necessary fulcrum, the lateral femoral condyle. If, on the other hand, ligamentous supportive structures resist the injuring force, grinding of the condyle of the femur into the lateral plateau of the tibia takes place, and either a splitting longitudinal or oblique fracture or a comminuted compressed fracture involving the tibial plateau results. It is inconceivable that in many such injuries the lateral meniscus should not be damaged.

As stated by Haldeman, "In man, articular cartilage has no power of regeneration, and the metaplasia of connective tissue into cartilage is rarely seen. Such metaplasia is more apt to result from a severe injury, with an accompanying destruction of subchondral bone, than it is to occur following injuries which involve the cartilage alone".

The bone pathology is described by Lee in his article on "Fractures of the Tuberosities of the Tibia", and he cites the studies of Barbilian on architectural structure and the disposition of bone trabeculae. In a sagittal section the trabeculae are separated into two systems—an anterior and a posterior system—which cross each other in an arch formation.

\* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons Boston, Massachusetts, on January 25, 1940.



The trabeculae always cross each other perpendicularly. This arrangement of the arches of the trabeculae, which become more horizontal as they approach the articular surface, accounts for the direction of the line of fracture. In frontal section each condyle has a separate set, arranged perpendicular to the joint surface. The more remote the line of fracture from the articular surface, the more vertical it will be. In cases resulting from direct massive force there is no particular pattern of fracture; it will vary with the degree and duration of the force applied. These theoretical statements are proved to be true by practical observation of injuries sustained in the manner described.

There is comminution of the lateral tibial plateau with depression of the articular cartilage. Occasionally a linear fracture with depression occurs. There may be tearing, crushing, and displacement of the lateral meniscus. Tears of the lateral ligament with fracture are unusual. Often there is a fracture involving the head of the fibula with disturbance in its relationship to the tibia. Occasionally injury to the external peroneal nerve has been reported but it has not been observed in the authors' series.

On examination, sometimes there may be seen a localized ecchymosis, the result of the injuring force. The knee is greatly swollen and exquisitely sensitive to pressure over the anterior half of the lateral tibial condyle. Lateral passive motion is painful, as is rotation of the tibia on the femur. The knee is limited in flexion and in extension, not so much by pain as by the hemarthrosis. The roentgenogram may

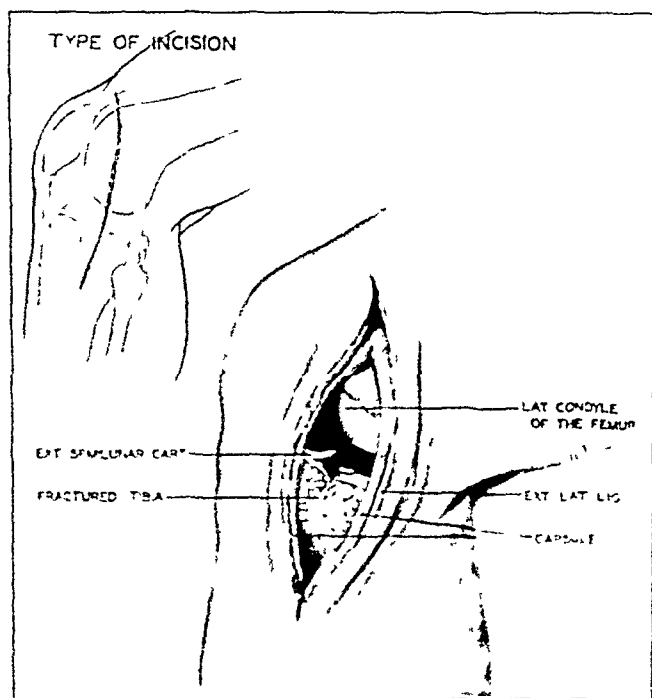


FIG. 1

Exposure of injured bone and meniscus.

give a deceptive picture of the total amount of damage. For example, it is the usual observation that the comminuted fracture rarely involves the entire condyle and, therefore, in the anteroposterior projections the posterior rim of the lateral condyle casts a shadow, which may obscure the degree of depression of the anterior aspect of the lateral plateau. For the same reason, a lateral film will show a normal shadow cast by the medial condylar plateau. How-

ever, comminution beneath the articular cartilage is well depicted. Those fractures falling into the vertical and oblique linear groups with a single large fragment are readily determined. The difficulty of estimating the amount of depression, and, therefore, of reaching the proper conclusions on the degree of injury to the meniscus is the rationale for a more radical treatment than is generally accepted.

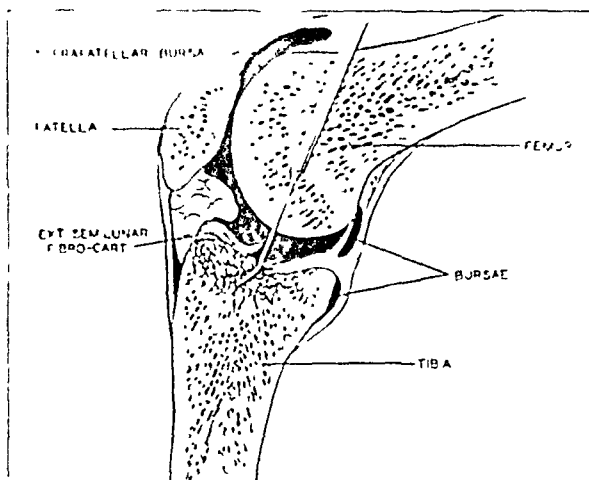


FIG. 2

Demonstrating approach from above and within the joint.

For the reasons mentioned, operation has been advised in many cases. To wait longer than the period necessary to determine the amount of serious circulatory damage is unwise. The approach is made through an incision over the lateral aspect of the knee, anterior to the head of the fibula, and of such length that the joint may be thoroughly inspected (Fig. 1). The comminution of the articular cartilage with dissolution of the spongy bone below is a constant picture. The lateral meniscus frequently reveals tearing, crushing, and displacement. The joint is thoroughly washed to remove blood clots and other debris. The lateral meniscus is then excised *in toto*. The fragmented articular cartilage is gently teased upward by means of a periosteal elevator. This procedure should be done from the upper or joint-surface aspect, so that evenness of the plateau may be assured (Fig. 2). This step accomplished, the spongy bone beneath should be packed and compressed by instruments until the plateau is firmly molded against the lateral femoral condyle. Closure, with reefing of the capsule if desired, is then done in the usual manner, and a plaster cast is applied from the toes to the groin, with the knee in a position of from 10 to 15 degrees of flexion.

Cases presenting a single major fragment with an oblique or vertical fracture are usually treated in a like manner, but often a transfixing screw is needed for better immobilization. Insertion of the screw is readily accomplished through the same incision. Whenever desired, a flanged bone clamp may be applied for the purpose of closer approximation prior to the insertion of the screw.

The period of immobilization has varied, but it is the opinion of the writers that long fixation is unnecessary. Motion in from four to six weeks seems desirable after experiencing difficulty in securing flexion in those earlier cases in which longer periods of splinting obtained. The use of counterbalanced suspension slings has been most helpful in initiating

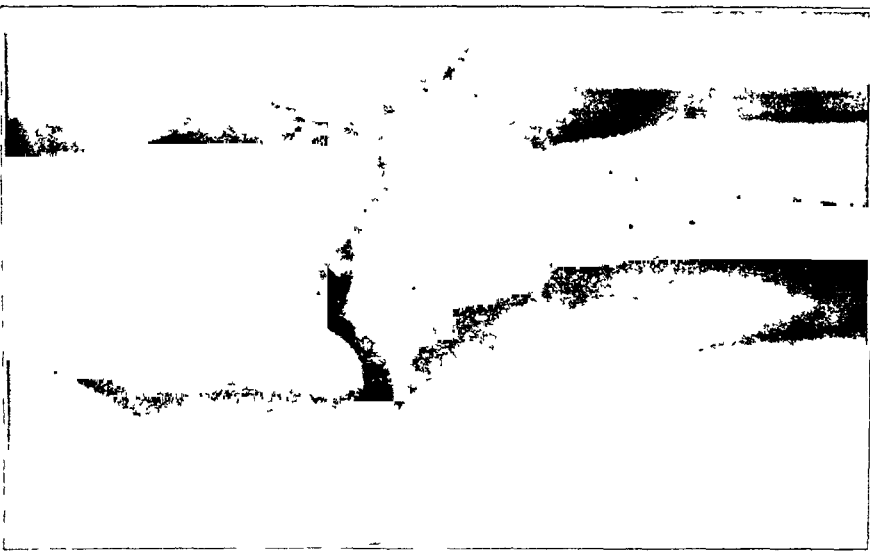


Fig. 3-C

Case 9. Anteroposterior roentgenogram, March 29, 1937 showing correction of the depression.



Fig. 3-B

Case 9. Lateral roentgenogram, March 19, 1937. This does not demonstrate the true deformity.



Fig. 3-A

Case 9. Anteroposterior roentgenogram, March 19, 1937, showing marked depression of lateral tibial condyle.

early painless motion. Weight-bearing on the injured knee should not be permitted for three months. At this time sufficient power in the quadriceps muscle will have been developed to establish good stability in the knee.

This paper is based on a study of twenty-three cases (Table I). Of these, fifteen, or 65 per cent., were due to direct violence from automobiles, and eight, or 35 per cent., were due to some type of fall. Sixteen, or 70 per cent., were treated by open reduction; seven, or 30 per cent., were treated by closed reduction and a cast. Of the cases treated by open reduction, removal of a meniscus was necessary in twelve, or 75 per cent. In this group, the medial meniscus was removed in one case, as compared to excision of the lateral meniscus in eleven cases. There was no case in which both menisci were removed. On inspection of the articular surfaces, the cruciate ligaments were intact in every case. Of the sixteen open reductions, some form of internal metal fixation was required in four, or 25 per cent. It was possible to follow and to study eighteen cases from five weeks to four years. In these cases the average time elapsing before weight-bearing was allowed was thirteen weeks.

Of the sixteen cases treated by open reduction, good functional results were obtained in nine, or 56 per cent.; these patients had active flexion beyond a right angle, complete extension, and normal stability. In one of these cases treatment resulted in moderate genu valgum, but with good function. In two cases fair functional results were obtained: one patient had limitation of flexion to 80 degrees, and the other lacked 15 degrees of complete extension; both have good stability and are able to be active and to perform all but strenuous activities. Two of the patients have been operated upon too recently to permit the drawing of final conclusions. However, in these two cases, at five and seven weeks respectively, from 15 to 20 degrees of active and passive motion is possible, while the lateral stability appears normal. In three cases we were unable to obtain any follow-up examination, but at the time of discharge the results were recorded as being satisfactory.

Of the seven patients treated by closed reduction, two, or 29 per cent. had normal functioning knees, and three, or 43 per cent., had limited motion, instability, and pain on use. Two others did not return for treatment or study.

#### ILLUSTRATIVE CASES

CASE 9. R. W., colored male, aged thirty-six years, was admitted to the hospital on March 18, 1937, following injury to the left knee, caused by an automobile. There was swelling, and any attempt at motion was very painful. At operation, the lateral meniscus was excised. The entire extremity was immobilized in a complete circular plaster cast from the groin to the toes inclusive. On April 2, 1937, the patient was allowed up in a chair, and on April 3, 1937, began walking with the aid of crutches.

CASE 11. J. W., white male, aged forty-six years, injured the left knee in an automobile accident on January 31, 1937. The usual signs of swelling, discoloration, and painful motion were present. On February 6, 1937, at open reduction, the lateral meniscus was excised. The entire extremity was immobilized in a complete circular

TABLE I  
SUMMARY OF TWENTY-THREE CASES OF FRACTURE OF THE TIBIAL PLATEAU

Case	Name	Sex	Age (Years)	Etiology	Reduction	Meniscus Removed	Fixation
1	F. W. B.	Male	38	Struck by automobile	Open		Cast
2	M. N.	Female	48	Automobile accident	Open (2)		Screw and cast
3	J. M.	Male	41	Fall in auto- mobile and street-car collision	Open		Screw and cast
4	B. L.	Male	36	Fall	Open	Lateral	Steinmann pin and cast
5	E. D. A.	Female	51	Struck by automobile	Open (2)	Medial	Cast
6	J. C.	Female	35	Struck by automobile	Open	Lateral	Cast
7	M. C.	Female	55	Struck by automobile	Open	Lateral	Cast
8	A. T.	Female	53	Fall	Open	Lateral	Cast
9	R. W.	Male	36	Struck by automobile	Open	Lateral	Cast
10	R. O. W.	Male	53	Struck by automobile	Open	Lateral	Cast
11	J. W.	Male	46	Struck by automobile	Open	Lateral	Cast
12	M. K.	Female	54	Struck by automobile	Open	Lateral (lateral ligament re- paired)	Cast
13	E. J. F.	Female	60	Struck by automobile	Open (disloca- tion of pa- tella)	Lateral (lateral ligament re- paired)	Cast
14	E. M.	Female	30	Struck by automobile	Open	Lateral	Cast
15	C. V.	Male	45	Fall	Open	Lateral	Cast
16	J. K.	Male	33	Fall	Open		Screw and cast
17	E. K.	Female	54	Fall in auto- mobile	Closed (refused operation)		Cast
18	R. E. A.	Male	57	Fall	Closed		Cast
19	E. D. O.	Male	56	Struck by automobile	Closed		Cast
20	H. A.	Male	31	Struck by automobile	Closed		Cast
21	G. B.	Female	35	Struck by automobile	Closed		Cast
22	F. P.	Female	64	Struck by automobile	Closed		Cast
23	H. R.	Male	43	Fall	Closed (refused operation)		Cast

TABLE 1—(Continued)  
SUMMARY OF TWENTY-THREE CASES OF FRACTURE OF THE TIBIAL PLATEAU

Period before Weight- Bearing	Remarks	Follow-Up Period	Follow-Up Examination			Function Result
			Flexion	Extension	Stability	
2 weeks		5 months	Lacks 15°	Normal	Normal	Good
1 weeks	Screw removed in 8 weeks	2 years	110°	Normal	Normal	Good
0 weeks	Screw not removed	4 years	110°	Normal	Normal	Good
2 weeks	Pin removed in 8 weeks	3½ years	Normal	Normal	Normal	Good
22 weeks	Returned to work as auditor	15 months	80°	Lacks 5°	Fairly good	Fair
4 weeks	Left hospital and did not return					
4 weeks	Pneumonia developed in 4th week	13 months	Normal	Normal	Normal	Good
11½ weeks	Progress reported by telephone	6 months	Normal	Normal	Normal	Good
?	Left hospital and did not return					
?	Left hospital and did not return					
8 weeks		2 years	100°	Normal	Normal	Good
12 weeks		6 months	Normal	Normal	Normal	Good
16 weeks	Pneumonia developed in 4th week	15 months	118°	Lacks 15°	Fairly good	Fair
10 weeks	Peritonsillar abscess developed in 2nd week	12 months	Normal	Normal	Normal	Good
Cast removed in from 5 to 7 weeks		5 weeks	15°	15°	Normal	Satisfactory progress
Screw removed in 12 weeks		7 weeks	20°	20°	Normal	Satisfactory progress
16 weeks		16 months	65°	130°	Very poor	Poor
12 weeks	Returned to work as farmer	6 months	Normal	Normal	Normal	Fair (pain use)
11 weeks	Patient left hospital and did not return					
14 weeks	Treated with prolonged physiotherapy	22 months	Normal	Normal	Normal	Good
12 weeks	Patient left hospital and did not return					
16 weeks		4 years	Normal	Normal	Normal	Good
12 weeks	Leg brace applied	6 months	65°	Lacks 40°	Poor (pain)	Poor



FIG. 1-A

Case 11. Anteroposterior roentgenogram, February 1, 1937, showing marked depression of the lateral tibial condyle with fracture of the fibula below.



FIG. 4-B

Case 11. Lateral roentgenogram, February 1, 1937. This does not demonstrate the true deformity.

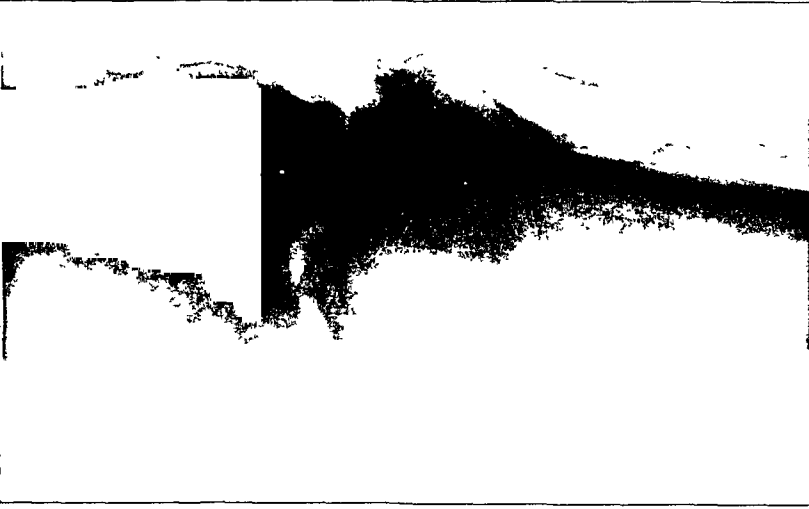


FIG. 4-C

Case 11. Postoperative roentgenogram, February 10, 1937, showing correction of the depression.



Fig. 5-C

Case 14. Postoperative anteroposterior roentgenogram, November 25, 1935, showing complete correction of the depression.

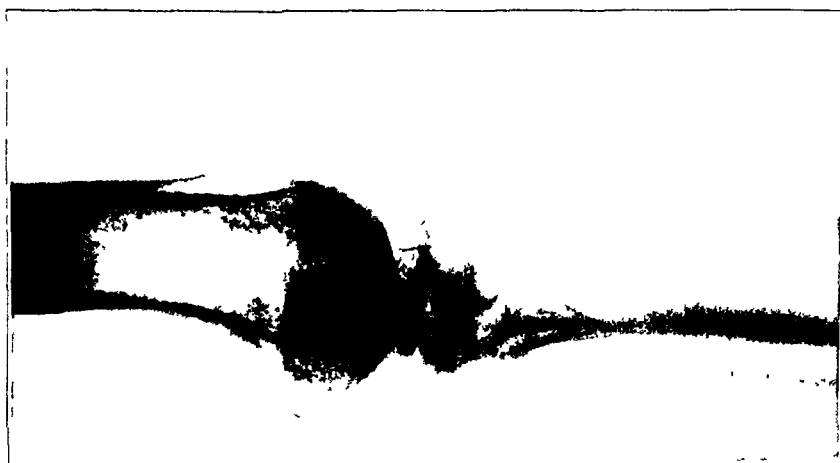


Fig. 5-B

Case 14. Lateral roentgenogram, November 17, 1935. This does not demonstrate the true deformity.

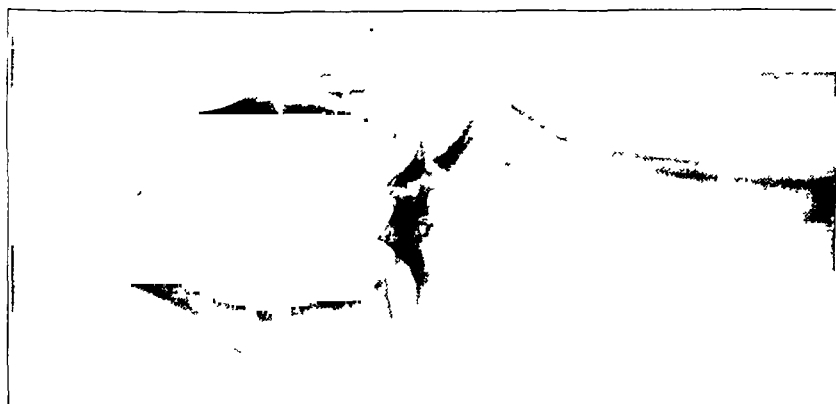


Fig. 5-A

Case 14. Anteroposterior roentgenogram, November 17, 1935, demonstrating marked depression of the lateral tibial condyle.



plaster cast from the groin to the toes inclusive. On March 2, 1937, the patient was up in a chair, and, on March 15, 1937, he was allowed to walk with the aid of crutches. On March 27, 1937, the cast was bivalved, and physiotherapy was started. Weight-bearing was begun on April 2, 1937. On January 31, 1939, flexion to 100 degrees was possible. Extension and stability were normal.

CASE 14. E. M., colored female, aged thirty years, was struck by an automobile on November 17, 1935, and sustained an injury to the left knee. Open reduction was performed on November 23, 1935. Much old blood was removed from the joint. The lateral meniscus was found to be damaged, and was removed *in toto*. The entire extremity was immobilized in a complete circular plaster cast from the groin to the toes inclusive. On December 26, 1935, the cast was removed, and the patient was allowed to use crutches. Weight-bearing was begun on February 3, 1936. On December 1, 1936, flexion, extension, and stability were normal.

It has been evident to the writers that the pathology of trauma demonstrated in cases of fracture of the lateral tibial condyle at exploratory operation—namely, the comminution of the articular cartilage, the gross crushing of the lateral meniscus, and the damage to the underlying spongy bone—has prompted a more vigorous and direct approach to the problem than is usually accepted. Long and many times permanent disability from pain, instability, and lost function, observed in conservatively treated cases, likewise has prompted the more radical measures. The inefficacy of the roentgenogram to demonstrate fully the true extent of the injury would also seem to argue for more frequent exploration.

By operation through a simple, not too extensive exposure—in which the damaged soft structures are removed, good contour is restored to the lateral tibial plateau at its weight-bearing surface, and packed subchondral bone is supplied for support and for more rapid fibrocartilage formation—many disconcerting disabilities may be prevented.

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# TUBERCULOSIS OF THE LARGE LONG BONES OF THE EXTREMITIES\*

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Tuberculosis of the shafts of the large long bones is rare in the United States. An extensive search of the English literature revealed but thirty-two reported cases.<sup>1 to 15</sup> A questionnaire, sent to 250 leading orthopaedic surgeons in the United States and Canada, however, produced an additional seventy-four† hitherto unreported cases, nine of them being from Canada. This paper is a discussion of these cases with a report of four new ones and a detailed study of an unusual case with multiple osseous tuberculoid lesions.

Every case in this series had been proved definitely to be tuberculous by microscopic section and animal inoculation, or by the latter method alone. Only lesions of the shafts—diaphyses and metaphyses without joint involvement—of the large long bones have been accepted. Eight unreported cases in which only the greater trochanter was affected were discarded as were four in which the clavicles alone were involved. The authors have included certain reported cases in which tubercle bacilli were present, but which appeared in the literature under other diagnoses.

## BONES AFFECTED (Fig. 1)

In ninety-five patients, 123 long bones of the extremities were affected. Seven patients had involvement of two bones; four, of three bones; two, of four bones; and one, of seven bones. It is interesting to note that in the last-mentioned patient, both scapulae, both clavicles, the skull, and the spine were also affected. The tibia was involved in thirty-six cases (29 per cent.), and the femur was affected in thirty-three instances (27 per cent.). This marked frequency of occurrence in these two bones was present uniformly regardless of the age group.

## AGE AT ONSET (Fig. 2)

Contrary to current opinion, shaft tuberculosis does not occur predominantly in childhood. Of this series of ninety-five patients, forty-six (48 per cent.) were twenty years of age or more at the time of onset, seven of them being over fifty. In thirty-five the onset took place within the age period of from one to ten; of these patients, twenty-two had shaft involvement before they reached the age of five. Surprisingly large was the group of twenty-eight patients in whom the onset occurred

\* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Boston, Massachusetts, on January 24, 1940.

† Fifteen of these were received after the charts had been completed. Analysis revealed that their addition would not appreciably affect the summaries. While most of the charts were based on ninety-five cases, 110 were actually studied.

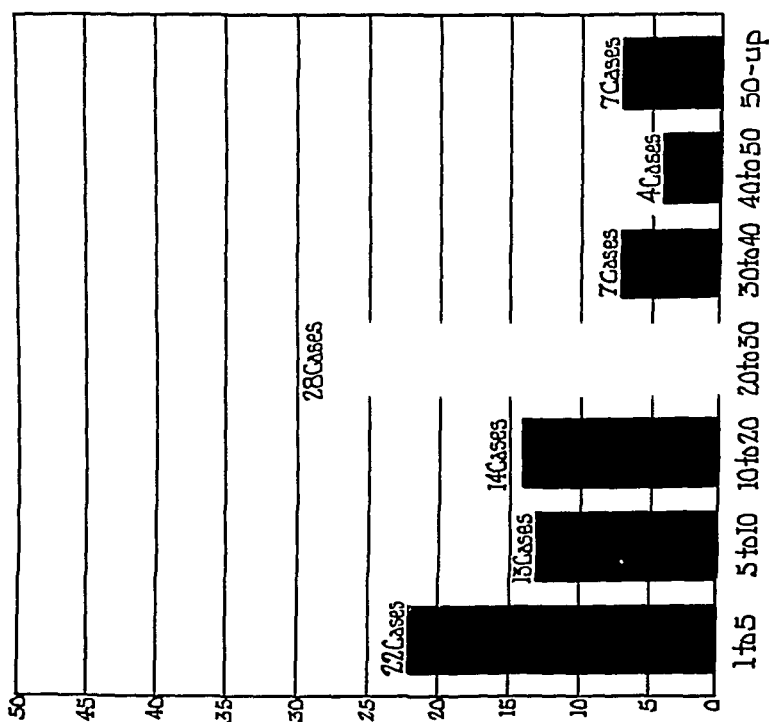


FIG. 2

Age at onset (95 patients). The first column includes one patient six months old.

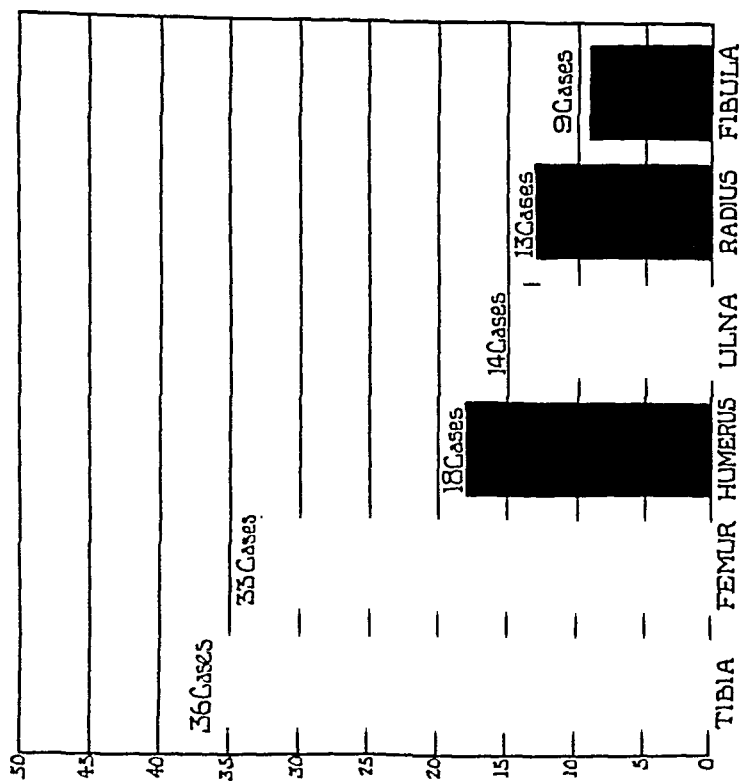


FIG. 1

Long bones involved (95 patients, 123 long bones).

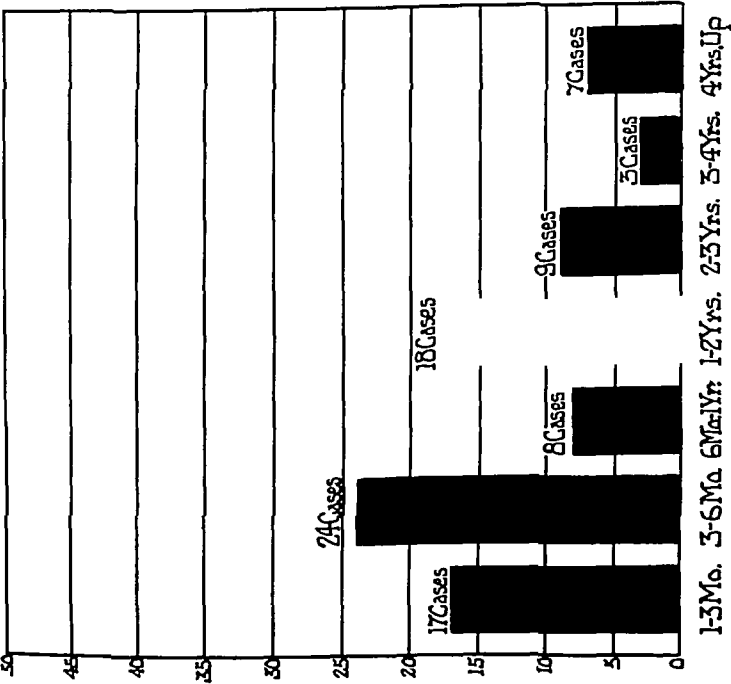


Fig. 3

Duration of symptoms (86 patients).

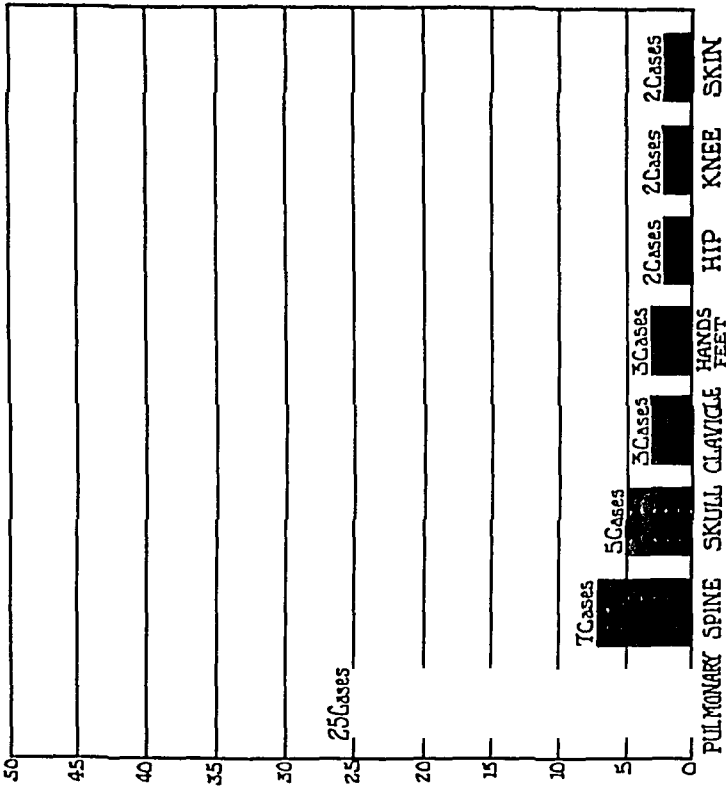


Fig. 4

Associated active lesions (37 patients).

TABLE I  
ANALYSIS OF THE EIGHTEEN DEATHS

Factors to Be Considered	No. of Cases
<b>Age:</b>	
Under 5 years.....	4
From 10 to 25 years.....	10
Over 25 years.....	4
<b>Multiple Long-Bone Lesions:</b>	
2 bones affected.....	2
3 bones affected.....	2
4 bones affected.....	1
<b>Associated Active Lesions:</b>	
Lungs.....	7
Joints.....	5
Flat bones.....	2
Meninges.....	2
Skin and cord.....	1
<b>Duration of Symptoms:</b>	
3 months or less.....	7
3 months to 1 year.....	7
Over 1 year.....	4
<b>Treatment:</b>	
Incision and drainage.....	7
Amputation.....	1
Excision.....	2
No treatment.....	8

between the ages of twenty and thirty. The youngest patient was six months of age and the oldest, seventy-five years. From these figures, it is not possible to agree with many investigators who state that the tubercle bacillus has a predilection for the richly vascular, growing bones of children. There is a possibility, however, that the disease, frequently of low virulence, may start in the bone months or years before the appearance of clinical signs.

#### DURATION OF SYMPTOMS (Fig. 3)

Of the eighty-six patients with known duration of symptoms, forty-one (48 per cent.) had had complaints for less than six months. Seventeen of this group had had symptoms for less than three months. On the other hand, thirty-seven (43 per cent.) had had complaints for over one year. The shortest time recorded was three days, and the longest was forty-four years. It may be stated that shaft tuberculosis is chronic in nature, since nearly one-half of the group had had symptoms for over

one year, and nineteen of them, for over two years. The results of surgical treatment of patients with a duration of symptoms of two years or more were just as satisfactory as were those in patients who were seen, and consequently treated, early. Apparently the body develops a high resistance toward the organism, and thereby is able to limit its extension.

#### ASSOCIATED LESIONS (Fig. 4)

Associated active tuberculous lesions were present in thirty-seven patients. Twenty-five patients had pulmonary infections; seven of these patients died. The spine was affected in seven cases; the skull, in five; and the hands and feet, in but three. Of the total series of ninety-five patients, only eleven had joint involvement. This is considered remarkable, since the tubercle bacillus has a specific affinity for the synovia. This fact may indicate that the organisms which affect long bones are of low virulence, and the synovia thereby is able to resist invasion. Seventeen of the thirty-seven patients with allied lesions, however, did not survive. Other sites of associated lesions were the meninges, skin, flat bones, middle ear, and small intestine.

#### ANALYSIS OF DEATHS (Table I)

Eighteen deaths occurred in ninety-five patients, of whom fourteen were under twenty-five years of age, four being under five years. Only five patients had more than one long bone involved, but seventeen (94 per cent.) had associated active lesions. Of these, seven had pulmonary infections, and five had joint involvement. Fourteen (78 per cent.) deaths were in patients with a duration of symptoms of one year or less. Seven of these patients had had complaints for less than five months. From these figures it appears that those patients who do not survive usually have an initial overwhelming infection. This statement is confirmed by the facts that eight patients, who were hopelessly affected, received no treatment of any form, and that seven others were treated by incision and drainage with diagnoses of severe extensive pyogenic osteomyelitis.

#### TREATMENT (Table II)

The end results were known in seventy-one of the ninety-five cases. Healing occurred in 92 per cent. of the thirteen patients treated by curettage or saucerization and closure. In a large series of cases treated in China—as reported by Van Gorder and by Hsieh, Miltner, and Chang—this method also produced excellent results. In three cases in our series, however, bone chips were packed into the osseous cavity following curettage. The addition of chips, or “*os purum*” as advocated by Orell, may aid in a more rapid repair of the defect.

Of the thirty-eight cases treated by incision and drainage, healing took place in twenty-five (66 per cent.); there was no improvement in six; and death occurred in seven. Many of these cases in which there were draining sinuses were not suitable for closure. Others, no doubt, were surgically

TABLE II  
ANALYSIS OF TREATMENT AND END RESULTS IN SEVENTY-ONE CASES

Treatment	No. of Cases	Results	No. of Cases	Associated Active Lesions	No. of Cases
Curettage or Saucerization and Closure	10	Healed	9	Lungs	2
		Unimproved	1	Urinary bladder	1
		Died	0		
Curettage or Saucerization and Bone Chips	3	Healed	3	Lung and adenoids Lung and hip	1 1
		Unimproved	0		
		Died	0		
Incision and Drainage	38	Healed	25	Lungs	2
				Lungs, intestine, and clavicle	1
				Lungs and spine	2
				Lungs, sternum, and skull	1
		Unimproved	6	Lungs	3
Amputation	3	Healed	2	Lungs and skull	1
		Unimproved	0		
Excision	4	Healed	2	Lungs	1
		Unimproved	0		
		Died	2	Knee Lungs	1 1
No Treatment	13	Healed	5	Lungs	1
		Unimproved	0		

In the group of thirteen patients who received no treatment, eight died, and five had spontaneous healing. A number of these patients were moribund upon admission, and others had such extensive involvement of bone and other tissues that operation was contra-indicated. This explains the high percentage of deaths in this group. Many authors, however, mention spontaneous healing in shaft tuberculosis. In this series of seventy-one cases with known end results, there were only five instances of spontaneous healing. The facts that thirty-seven patients had had symptoms for over one year and that nineteen had had complaints for over two years before being treated demonstrate the fallacy of the inference that healing might eventually have taken place in more patients if surgery had been delayed.

Comparison of results in the methods reported is not entirely conclusive, because factors relating to the extent of a particular lesion and the general condition of the patient would influence the outcome regardless of the procedure used. Such data could be procured only in full case reports. The groups, nevertheless, are large enough to warrant fairly definite conclusions. A fundamental principle in treating tuberculosis is to avoid secondary infection. This is particularly applicable in the treatment of osseous lesions. Incision and drainage, therefore, both theoretically and practically, is an unsound treatment. From this study of seventy-one cases with known end results, it is apparent that curettage or saucerization and closure is the treatment of choice. It has the highest incidence of healing; it produces minimal surgical trauma; it is applicable to all lesions, regardless of location; and it causes less eventual deformity.

#### CASE REPORTS

CASE 1. W. H., a white female, aged fourteen years, was admitted to the Texas Scottish Rite Hospital in April 1931. The past and family histories were irrelevant. The patient stated that pain in the left mid-thigh had developed one year before admission. There was no history of trauma. A slight elevation of temperature had persisted for several weeks, but there had been no heat or redness of the extremity. A double hip spica had been applied, with no improvement at the end of one month. A few weeks previous to admission the pain had been more severe, but the patient had continued to bear weight on the affected leg.

Physical examination revealed tenderness to pressure and moderate swelling over the upper shaft of the left femur. Moderate muscle spasm was present about the hip. No heat or redness was noted. Atrophy amounting to one centimeter was present in the left mid-thigh. (See Figure 5-A.)

Tuberculin tests down to 1 to 100 dilutions were negative, as were all laboratory studies. A tentative diagnosis of non-suppurative osteomyelitis or possible osteogenic sarcoma was made. Saucerization with closure was done in May 1931. No definite diagnosis was made from biopsy. One year later a mass of grayish tissue and bone sand was removed, and a positive diagnosis of tuberculosis was made by microscopic studies. At this time, a cystic lesion (Fig. 5-C) had developed in the proximal end of the right humerus.

The patient has been observed periodically up to the present time. The left femur has remained healed; there is shortening of one centimeter with limitation of motion in the hip. Without treatment the lesion of the humerus healed completely in one year.



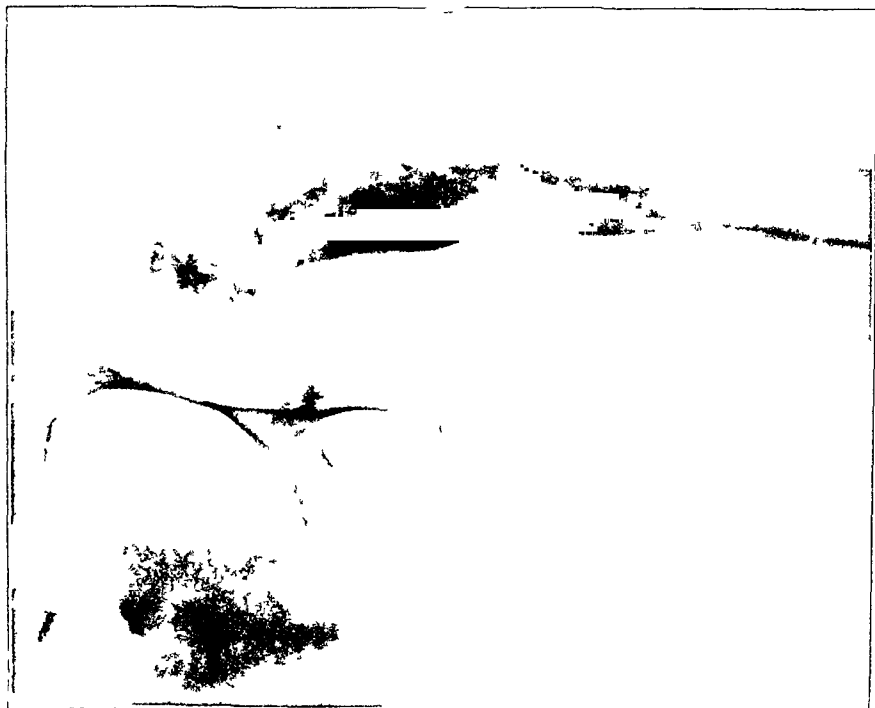


FIG. 5-B

Case 1. Left femur two years after saucerization and closure.



FIG. 5-A

Case 1. W. H. Tuberculosis of shaft of left femur. Before operation.

FIG. 5-D  
Case 1. Lesion of right humerus healed.

FIG. 5-C  
Case 1. Associated lesion in proximal end of right humerus.

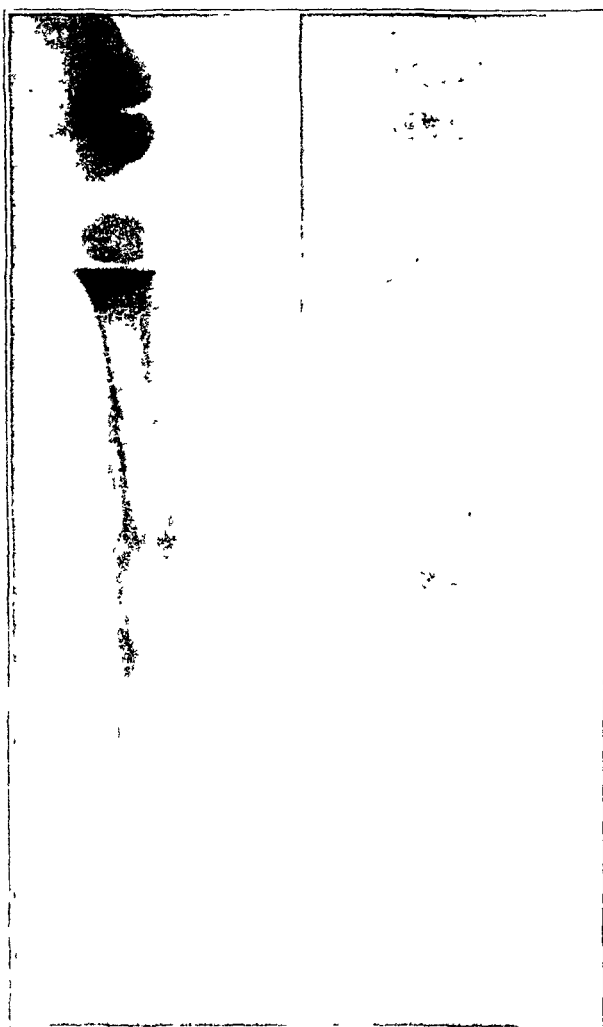


FIG. 6

CASE 2. J. H. Microscopic diagnosis: tuberculosis of left tibia.

lower end of the left femur, was seen in the latter part of 1939. Saucerization was done, and the wound was closed. Examination of the tissues showed tuberculosis. Healing was by primary union, but final results are to be determined.

CASE 4. L. J., a colored male, aged six years, also seen in 1939, had pulmonary tuberculosis, cervical adenitis, active infection of the left hip, and an osteoperiosteal lesion of the left fibula. Examination of the tissues was positive for tuberculosis. Treatment consisted in excision and packing. The final result has not been determined, but the prognosis is poor, since preoperative ulceration and multiple associated lesions were present.

#### PATHOGENESIS

The pathogenesis of bone tuberculosis has not been definitely established. Fraser states: "healthy bone cannot easily be infected with tuberculosis; its marrow must first undergo a gelatinous or fibromyxomatous degeneration, and such a degeneration is the result of a tuberculous

CASE 2. J. H., a white female, aged thirteen months, was admitted to the Texas Scottish Rite Hospital (Service of Dr. R. Jackson) in March 1939. The patient's mother had had active pulmonary tuberculosis during pregnancy. Efforts to produce an abortion were unsuccessful.

Pain in the left mid-tibia of one week's duration was present on admission. There had been no elevation of temperature at any time; the patient's general condition was good. On physical examination the skin over the tibia was slightly red, with increased heat; marked tenderness to pressure was noted; no inguinal adenitis was present.

Urinalysis and blood studies were negative, as were also serum tests for lues. A biopsy was done, and a microscopic diagnosis of tuberculosis was made. (See Figure 6.)

Treatment consisted in curettage and closure. The child was discharged with an upper-thigh plaster cast, and her general condition had improved when seen four months later.

CASE 3. M. J., a white female, fifteen years of age, with an infiltrative lesion at the

toxemia and of a tuberculous endarteritis of the vessel supplying the bone. . . ." He suggests that the bacilli probably are released originally by an extravasation of blood from a ruptured vessel weakened by endarteritis. The direct cause may be due to slight trauma. Karsner, quoting S  n  que, says that trauma may be an etiological factor, in that it may awaken a latent disease rather than establish a point of lowered resistance for the lodgment of organisms. Kaufmann points out that trauma may play a part, since the great majority of cases of bone tuberculosis are found in men. In our series 70 per cent. of the cases were in males.

Kolodny upholds the embolic theory. Koenig was the first to suggest the embolic form of pathogenesis, when he noted the frequent wedge-shaped sequestra. Lexer, in 1904, showed that the capillaries of the epiphyseal, metaphyseal, and diaphyseal blood systems from the nutrient artery do not anastomose, but are end vessels. Kolodny confirmed these findings and concluded that the parallelism between the frequency with which certain skeletal regions are involved in tuberculosis and the abundance of their blood supply strongly supports the embolic theory.

Boyd emphasized the fact that, in tuberculosis of long bones, bone destruction is usually dominant over bone formation, although there is a marked tendency toward limitation of spread and spontaneous healing, owing to the fibrous-tissue formation so characteristic of tuberculosis in the lungs and in other organs. Fraser found in experimental studies that a follicle is formed in the marrow, consisting of giant cells, epithelioid cells, and lymphocytes. By amalgamation of these follicles, a relatively large mass is developed. Central caseation begins with consequent peripheral fibrous-tissue formation to limit the spread. If the caseation is predominant, then the disease advances. If, on the other hand, the peripheral resistance is adequate, the disease remains localized. Fraser classifies tuberculous bone lesions into four distinct forms: the encysted, the infiltrative, the atrophic, and the hypertrophic. Distinguishing characteristics in some of these types may be noted in the roentgenograms in the report of the following case of multiple bone lesions, tuberculoid in nature, without proved diagnosis.

#### CASE REPORT—MULTIPLE LESIONS TUBERCULOID IN NATURE

CASE 5. J. M., a white male, aged seven years, was admitted to the Texas Scottish Rite Hospital on October 13, 1937. The family and past histories were irrelevant. Eight months prior to admission, the patient had fallen from a see-saw to the ground, sustaining contusions on both knees and the left wrist. About this same time the parents had noticed swelling above the right elbow and of the right mid-leg. No pain, fever, or malaise had been present at any time, and the patient had remained normally active. He had gained in weight and height at normal rates. Serum tests for syphilis had been negative two months before admission.

#### *Physical Examination*

Physical examination revealed localized swelling of the distal half of the left radius with mild pain on pressure; on the posterior portion the bone was compressible; there

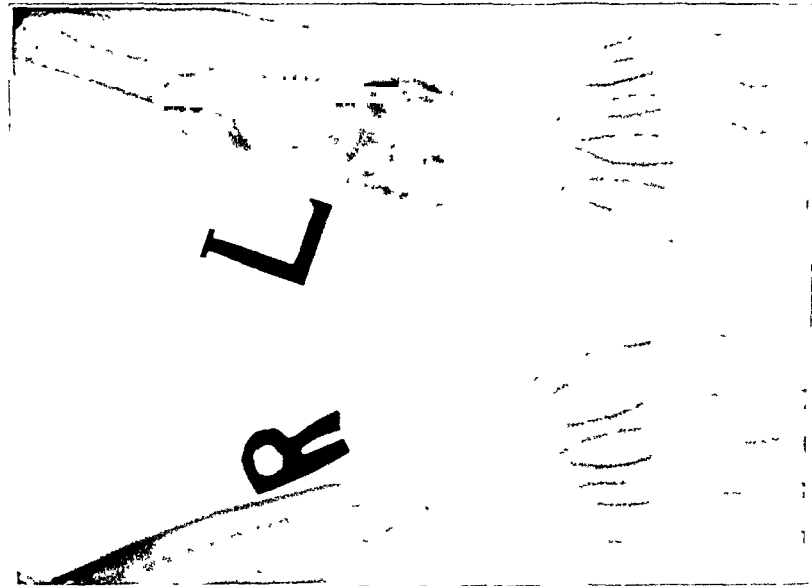


Fig. 7-A



Fig. 7-B

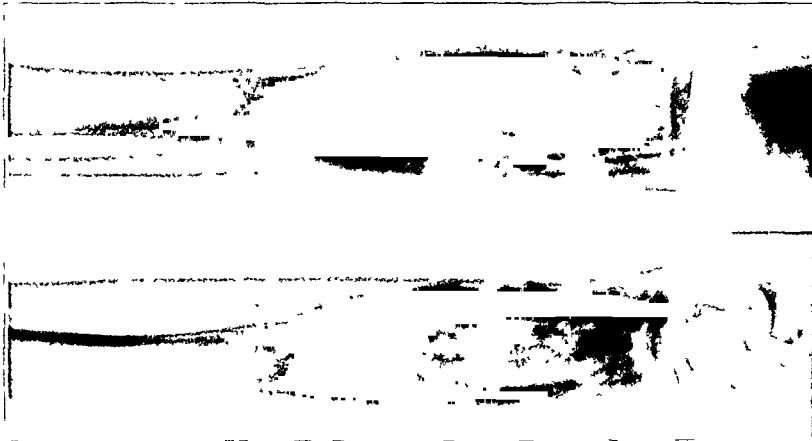


Fig. 7-C

Case 3. J. M. Tuberculous lesions during first year of observation (four bones involved).

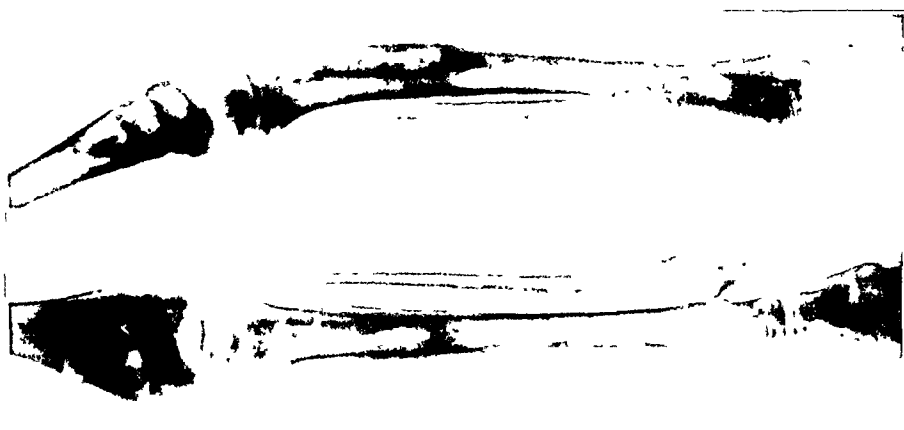


FIG. 7-F

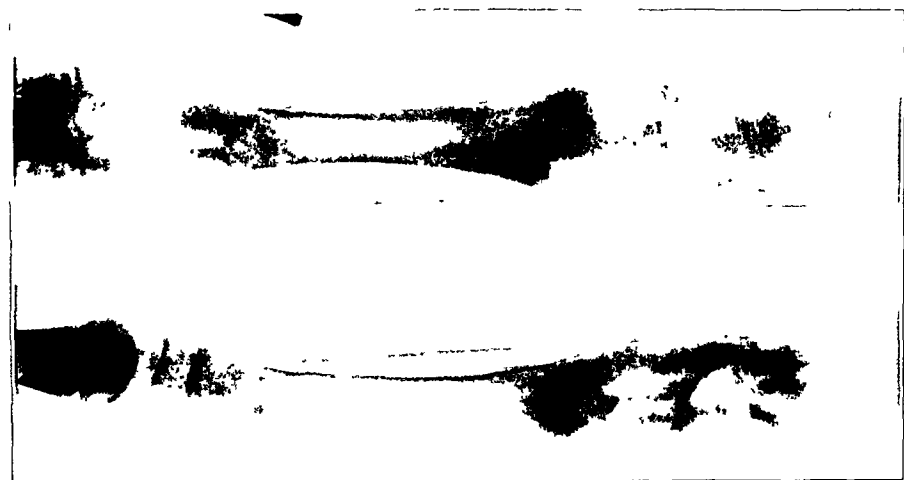


FIG. 7-E

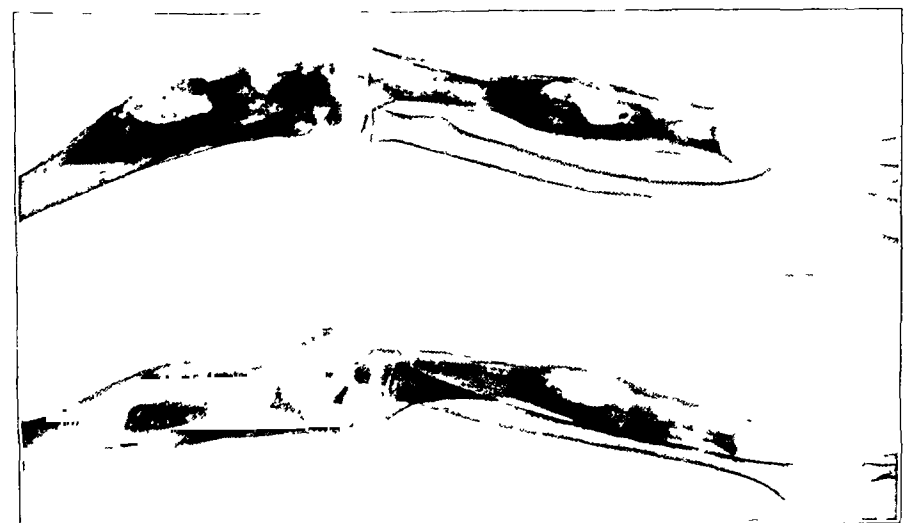


FIG. 7-D

Case 5. Character of lesions during second year of observation.

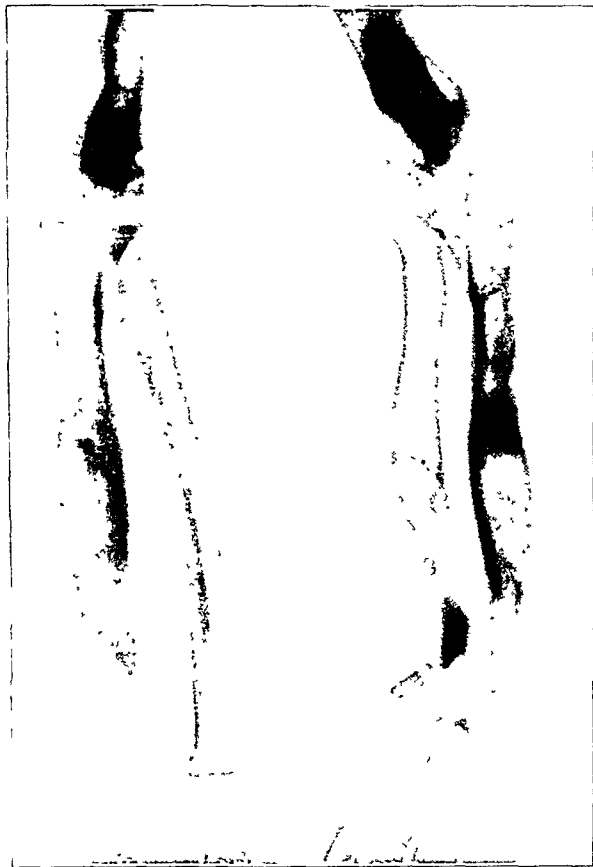


FIG. 7-G

Case 5. Third year of observation. Healing in progress.

White blood cells—14,200  
 Polymorphonuclear neutrophiles—58 per cent.  
 Lymphocytes—40 per cent.  
 Monocytes—2 per cent.  
 Coagulation time—3½ minutes  
 Serum calcium—10.1 milligrams  
 Serum phosphorus—4.6 milligrams  
 Total urinary calcium output in 48 hours—1.5 grams  
 Urinalysis—negative  
 Serum tests for syphilis—negative.

#### *Surgical Treatment*

November 1937: Biopsies of left radius and right tibia.  
 January 1938: Curettage of distal half of left radius.  
 February 1938: Aspiration of left chest; no fluid found.  
 March 1938: Curettage of distal third of right humerus.  
 December 1938: Biopsy of left fibula.

#### *Pathological Findings and Diagnoses \**

*Material from left radius and right tibia:* Tuberculous osteitis, chronic, active, progressive, and destructive.

*Material from right humerus:* Chronic destructive osteitis; etiology not determined.

\*These histological studies were made by Frederic Parker, Jr., Boston; C. H. Hatcher, Chicago; George T. Caldwell, J. L. Goforth, and A. B. Cairns, Dallas.

was no heat or redness. The distal third of the right humerus showed moderate bone enlargement; no tenderness to pressure could be elicited; and there were no signs of infection. The distal half of the right tibia showed marked bone enlargement; there was no tenderness to pressure; and no inguinal adenitis or any other signs of inflammation could be observed. Weight-bearing on the affected leg caused no pain. The left chest showed signs of consolidation of the left lower lobe of the lungs.

#### *Roentgenographic Examination*

Roentgenograms (Figs. 7-A, 7-B, and 7-C) were taken and interpreted as showing a chronic form of bone destruction, with some osseous formation. All the lesions appeared to have the same etiology, but seemed to be in different stages of progress. There was fibrosis of the left lower lobe of the lungs.

#### *Laboratory Studies*

The laboratory findings were as follows:

Red blood cells—4,300,000  
 Hemoglobin—80 per cent.

*Material from left fibula:* Caseous necrosis of chronic inflammatory granulation tissue, probably tuberculous.

Inoculation of three guinea pigs was negative for tuberculosis.

*Course* (Figs. 7-D, 7-E, 7-F)

Clinically the patient has continued to improve. In none of the lesions did sinuses develop and he has not complained of pain. On several occasions a productive cough has developed, but the sputum on repeated examinations has been found negative for acid-fast organisms. The patient has been seen over a period of three years; he has remained in bed most of that time, but has continued to grow without marked deformity. Roentgenographically, there was a marked spread of the disease for ten months following the first examination. From that time there has been progressive healing in all the lesions (Figs. 7-G and 7-H).

#### DISCUSSION

From clinical and roentgenological viewpoints, a differential diagnosis would include syphilis, pyogenic osteomyelitis, coccidioidal infection, Jüngling's disease and Boeck's sarcoid, and tuberculosis. Ewing's and osteogenic sarcomata were not considered, because of the multiplicity of lesions. Conditions occasionally producing bone lesions of a similar appearance—such as actinomycosis, blastomycosis, leprosy, and disturbances in lipid metabolism—were also excluded, because no characteristic findings in these diseases were present in the case under discussion.

#### *Syphilis*

Lues, congenital or acquired, must be given first consideration in such a widespread bone involvement. All forms of shaft lesions may occur in untreated syphilis, but the most characteristic exhibits a heavy dense infiltration of bone through the cortex, marked subperiosteal bone, and partial or complete obliteration of the medullary canal. Interference with the blood supply and gumma formation may result in the production of irregular cavities and areas of bone destruction. If there are two bones in a segment, as in the arm or the leg, the involved bone is usually increased in length and is bowed.

In our case it was only after histological and serological studies that

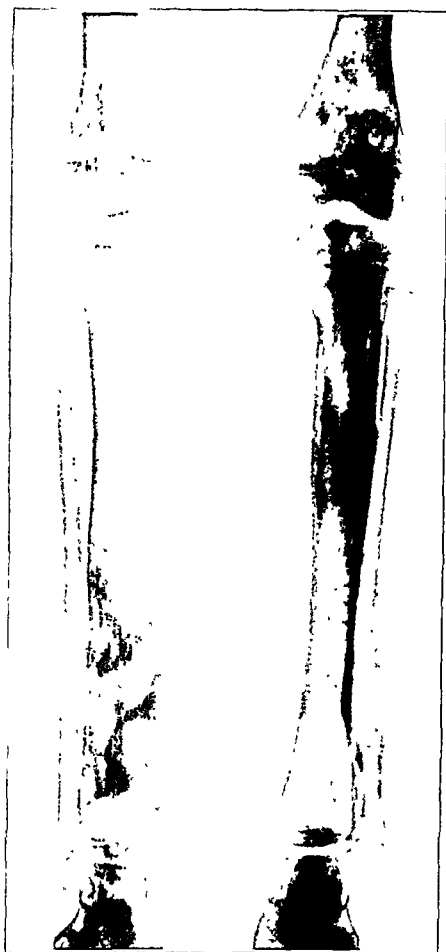


FIG. 7-H

Case 5. Third year of observation. Healing in progress.



syphilis as the etiology was eliminated. Eagle, Kahn, Kline, and Wassermann tests were negative. Provocative tests were negative. The father's serum was also negative for lues; the mother was not available for study. In addition, the patient did not have any stigmata of lues, and he showed progressive healing without antiluetic treatment.

### *Chronic Pyogenic Osteomyelitis*

This disease may involve multiple bones and may be a combination of Brodie's abscesses and the sclerosing non-suppurative type of osteomyelitis described by Garrè. These forms very closely resemble, clinically and roentgenographically, tuberculous bone lesions. In several instances, however, in our series the bone infection was fulminating and widespread and showed all the signs and symptoms of an acute suppurative osteomyelitis. In the case just described, although there was extensive involvement, no acute onset, no elevation of temperature, no pain at any time, no sinus formation, and no sequestration were noted, and the overlying soft tissues were not affected. Bacteriological studies were also negative. We were able, therefore, to exclude as a diagnosis both the acute and the chronic forms of pyogenic osteomyelitis.

### *Coccidioides*

Bone involvement in generalized coccidioidal infection is common<sup>23, 25</sup>, and the lesions closely resemble, both clinically and pathologically, tuberculous bone infection<sup>21, 28</sup>. It is essentially a destructive osteomyelitis, arising centrally, subperiosteally, or by extension from adjacent abscesses. As in other granulomata, there is a central ischaemia, with a tendency toward caseation and liquefaction. The condition may be fulminating<sup>38</sup> or chronic in nature<sup>20, 35</sup>. An associated fibrosis of the lungs frequently is found. The epiphyses and tubercles of the long bones are most often affected.<sup>19</sup> Many authors have pointed out that coccidioidal and tuberculous bone lesions cannot be differentiated accurately by roentgenograms alone. Definite proof of coccidioidal infection, however, is not difficult to obtain by microscopic study or by animal inoculation.

Coccidioidal infection was excluded in the case under discussion for the following reasons: The bone lesions involved no tubercles or epiphyses; the course of the disease was exceedingly chronic without systemic reactions; the lesions showed spontaneous healing; repeated microscopic examinations of biopsy material were negative; and inoculations into male guinea pigs produced no characteristic lesions.

### *Jüngling's Disease and Boeck's Sarcoid*

Jüngling described a condition of multiple cystic lesions in the metacarpals, metatarsals, and phalanges of young adults. In his series a few long bones were affected. He believed the lesions to be tuberculoid and to be a peculiar form of tuberculosis. He emphasized the close association of this bone disease with Boeck's sarcoid and lupus pernio.

"Multiple benign sarcoid" was the name given to the disease reported by Boeck, which is characterized by skin lesions and enlarged lymph nodes. He considered the condition to be due to a non-virulent form of the tubercle bacillus. Schaumann believes that the disease is due to a non-acid-fast, possibly filtrable, form of the tubercle bacillus. Hodges, Phemister, and Brunschwig mention that many present-day investigators are convinced that a sarcoid is nothing more than an unusual reaction of ordinary tuberculosis working in highly resistant tissues. According to Ellis, the etiology of the sarcoid is debatable, but is probably tuberculous. In regard to the bone lesions, it is his opinion that frank cystic tuberculous osteitis has been confused in recent literature with Jüngling's disease.

Several of the postulates outlined by Jüngling are fulfilled in our case. There were no sequestration, sinus formation, extension into joints, or positive reactions to tuberculin tests. Despite pulmonary involvement, no tubercle bacilli could be found in the sputum. Stains, cultures, and animal inoculations with biopsy material were negative for this bacillus. The general health of the patient also remained excellent. The facts which are against Jüngling's disease are: The skin was not involved; the bones of the hands and feet were unaffected; marked caseation was present; and tissue from two lesions was diagnosed microscopically as tuberculosis.

### *Tuberculosis*

The roentgenographic appearance is in accord with three distinct forms of tuberculous lesions. The encysted type shows definite cystic formation in the metaphysis with but slight bone reaction. The atrophic form has marked metaphyseal atrophy and expansion, the latter being due to an excess of periosteal bone formation, which has been undermined by the disease process. The infiltrating type has marked periosteal reaction, sclerosis of the bone, and extensive involvement of the shaft.

The gross appearance of the lesions demonstrated at operation are in line with a diagnosis of tuberculosis.<sup>16</sup> In the encysted and atrophic forms the bone shell was soft and thin, and the cavities were filled with a grayish granular material with a central area of caseation. A moderate amount of bone sand was present with no sequestra. In the infiltrating form there was marked subperiosteal new bone, and the cortex was heavy and dense. The cavity, however, contained caseation and bone sand as in the other two forms.

Studies of tissue taken at biopsy in several laboratories were not conclusive. In none of the tissue were found the typical cells of Langhans, but from two lesions the histological pattern warranted a diagnosis of tuberculosis. This diagnosis could not be substantiated, however, by sections from other lesions. Furthermore, three guinea-pig inoculations were negative for acid-fast organisms, and the Mantoux tests were persistently negative down to a dilution of 1 to 100.

A tentative diagnosis of tuberculosis has been made in the case which we have reported, although it has not been confirmed during the three years in which this patient has been observed. The history and clinical behavior are consistent with those of tuberculosis. The multiplicity of bone lesions, in both diaphyses and metaphyses, does occur as shown by our charts. These findings do not positively prove or disprove tuberculosis. They do suggest, however, that this patient's condition may be due to a non-virulent form of the tubercle bacillus, as reported by Boeck and later by Jüngling. In our opinion, the process is one of an atypical tuberculous osteomyelitis, due, perhaps, to an attenuated organism, and the prognosis for ultimate recovery is good.

#### CONCLUSIONS

1. Shaft tuberculosis is essentially a chronic disease. In rare instances it may be fulminating and rapidly progressive.
2. The tubercle bacillus does not have a predilection for the growing bones of children, since, in nearly one-half of the cases reviewed, the disease started in patients over twenty years of age.
3. Of the large long bones, the tibia and the femur are most frequently affected.
4. Active pulmonary and other tuberculous lesions are frequently associated with shaft tuberculosis.
5. The treatment most frequently used was incision and drainage, due, in part, to early diagnosis of pyogenic osteomyelitis.
6. Saucerization and packing is an effective treatment in the presence of draining sinuses.
7. Curettage or saucerization and closure in cases without sinuses, practically and theoretically, is the treatment of choice in tuberculosis of the long bones of the extremities.

The authors take this opportunity to express their appreciation to the following surgeons who provided data on their unpublished cases: Roger Anderson, David M. Bosworth, Guy A. Caldwell, Walter F. Carruthers, M. S. Danforth, Frank D. Dickson, Juan Farill, Robert V. Funsten, R. K. Ghormley, R. I. Harris, Paul U. Hartman, R. N. Hatt, E. W. Hauser, Myron T. Henry, J. T. Hodgen, R. T. Hudson, Samuel Kleinberg, Edward LeCocq, C. L. Lowman, W. R. MacAusland, A. P. MacKinnon, D. M. Meekison, O. L. Miller, J. S. Norman, J. F. O'Brien, W. W. Plummer, E. M. Regen, M. W. Rohn, Alan DeForest Smith, Arthur Steindler, G. B. Stephenson, G. M. Taylor, T. E. Wyatt, and Philip D. Wilson.

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# EVALUATION OF WOLFF'S LAW OF BONE FORMATION

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This analysis was prompted by a study of Murk Jansen's treatise, "On Bone Formation",<sup>5</sup> in which he claimed to have demonstrated the untenability of Wolff's law of bone formation. Wolff<sup>18</sup>, in 1870, depicted the structure of a bone as representing an exact symbol of external forces which were operative upon it and formulated his "Law of Transformation of Bone", in 1892<sup>19</sup>, which stated that wherever stresses of pressure and tension are caused in bone, be it by pressing forces or by pulling, formation of bone takes place. Jansen objected strenuously to this principle and advanced many arguments to show that Wolff's deductions were fallacious and that tension will result in atrophy of bone, whereas pressure constitutes the only trophic stimulus. His deductions were based on a study of bone trabeculae of sections of normal and pathological bone taken from parts of the skeleton where stress is greatest, such as the neck of the femur, and in such pathological conditions as bony ankylosis of the knee in flexion and ankylosis of a kyphotic spine. He concluded that tension is unfavorable to bone growth, and that the bone elements place or displace themselves in the direction of functional pressure. He also stated that wherever bone formation is to be promoted, as in fractures and bone transplants, it cannot be expected, on any reasonable ground, from tension although it can be anticipated from pressure. The clinical importance of this postulate is obvious to the surgeon who attempts to transplant bone where undue tension will be exerted on the graft. However, there is ample clinical evidence to show that tension will not cause the death of the bone graft, but will even stimulate its growth to a degree that is adequate to resist successfully the tension stress.

Other observers have written on this interesting question, and the trend of opinion inclines to a modified view of Wolff's law. Volkmann<sup>17</sup> and Hueter<sup>7</sup> contended that pressure inhibits growth of bone, while release of pressure favors it. Meyer<sup>10</sup>, in 1867, described the architecture of cancellous tissue, distinguishing between the pressure-sustaining elements. Steindler<sup>15</sup> believes that certain modifications of the original Wolff's law must be introduced, taking into account the fact that the stimulating effect of functional pressure has certain biological limits, both in intensity and in duration, and that the reaction to tension stresses is somewhat different from that to pressure.

Bone grafts are sometimes transplanted to parts of the skeleton where they are undoubtedly under great tension, and, if the existence of this tension be recognized and the bone graft be observed to retain its vitality and to exhibit hypertrophy, then it may be fairly deduced that tension is



FIG. 1-A

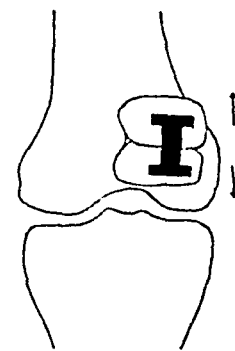


FIG. 1-B

Roentgenogram and schema, showing H-shaped bone graft inlaid across ununited fracture of patella. Arrows indicate line of tension stress exerted by quadriceps muscle and patellar tendon upon the graft, which does not atrophy and which maintains coaptation of fragments. Bone repair occurs in spite of complete absence of pressure stress.

not necessarily detrimental to osteogenesis. Former investigations on this subject were made by analyzing post-mortem specimens of the skeleton and accounting for the amount of bone deposition or atrophy on the basis of stresses supposed to have been present during life. However, this is unsatisfactory in so far as different observers are in disagreement as to whether tension or pressure was acting on the specimen in question. For example, in the classic studies made by Roux<sup>13</sup>, in 1883, the specimen consisted of a knee joint ankylosed in 80 degrees of flexion. He assumed that the concave side was subjected to pressure by the weight of the body in walking, but Murray<sup>12</sup> questions whether such a limb could have been used in walking unless some device were attached to the knee. Jansen, in criticizing Roux, goes on to say that the convex side of the knee in question is frequently under pressure instead of tension, as Roux postu-

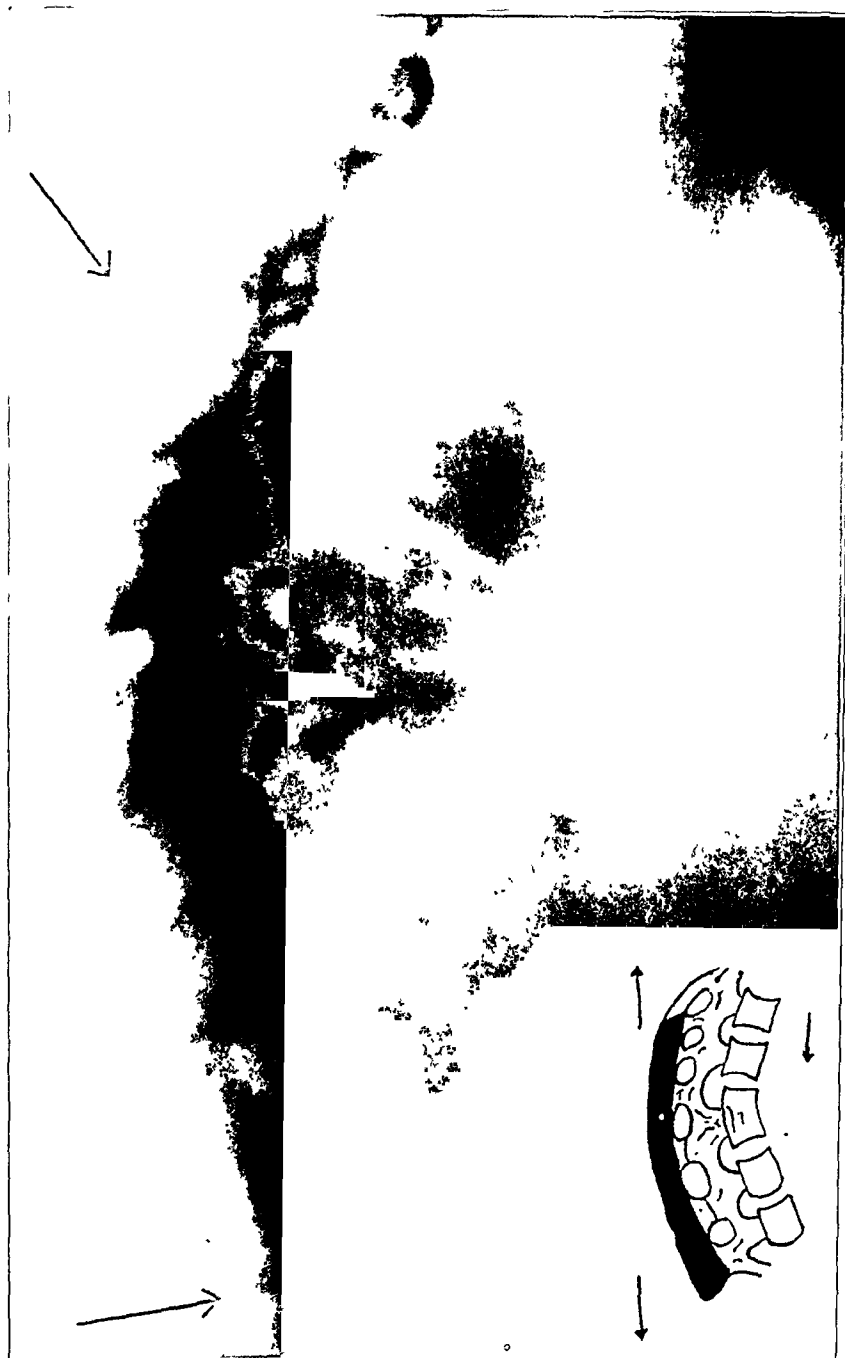


FIG. 2-A

FIG. 2-B

Roentgenogram and schema of spine, fifteen years after fusion of spine for Pott's disease by tibial bone graft. The tibial graft is under extreme tension, but responds favorably by exhibiting hypertrophy in accordance with Wolff's law. Arrows in schema indicate direction of stresses. Shaded area denotes bone graft.





FIG. 3

Tuberculosis of lumbar spine, treated by Albee spine fusion in 1918. Roentgenogram, taken twenty-one years after operation, shows bone graft to be almost three times as large as when originally implanted,—a reaction to the great stresses acting on the lumbosacral junction.

tension constantly,—from the moment that the bone tenaculum which holds the fragments together while the graft is inserted is removed, throughout the postoperative period of immobilization maintained by the muscle tone of the quadriceps, and finally, in the stage of active motion. The element of pressure is minimized here, and to study the progress of such a case results in the conviction that pressure stress is not indispensable for the growth of bone. Unfortunately, the enlargement of the graft cannot be observed, because the graft is in contact with the patella on all its borders.

To study this phenomenon, one must turn to the bone-graft operation in Pott's disease with advanced kyphosis (Figs. 2-A and 2-B).

lated, because of the weight of the limb when elevated, the pull of the quadriceps, vibrating movements, etc. Thus it is apparent that before deductions as to the influence of tension or of pressure can be made, one stress must be isolated from the other and the effects of each studied separately. Studies upon parts of the normal skeleton that are undoubtedly under tension during its normal function, such as the junction of bone and tendon, have not been satisfactory. Several of the operations devised by present-day bone surgeons afford the opportunity to study the effect that long-continued tension has upon bone formation and to provide the basis for this re-evaluation of Wolff's law.

In Albee's operation for ununited fracture of the patella<sup>2</sup>, an H-shaped bone graft is inlaid across the fracture line, so as to coapt the fragments and to resist the pull of the quadriceps tendon (Figs. 1-A and 1-B). It is apparent that the bone cells in the bone graft are under

Here, too, the bone graft is placed in an environment of tension. This can be confirmed at the operating table when the inter-spinous ligaments are found to be extremely taut, due to the collapse of the vertebral bodies. Campbell<sup>5</sup> and Steindler<sup>14</sup> mention the risk of fracture of the graft in this type of case, because of the extreme tension present, but Albee eliminates this complication by using heavy, flexible grafts in the so-called "bundle-of-reeds" method. Figure 2-A is a roentgenogram of a spine taken fifteen years after fusion of the thoracic region. After the patient began weight-bearing, this graft was constantly under tension, due to the fact that in this region the line of gravity passes anterior to the vertebral bodies with a resultant tendency of the spinous processes to diverge. One of the functions of the graft is to prevent this tendency by fusing the spinous processes, thus precluding further deformity. Here, again, we have an example of bone growth in the presence of tension. The bone graft in the spine lends itself to study, because it retains its identity throughout the life of the individual, enabling its "life cycle" to be followed. This is not so in the case of ununited fracture of a long bone, because of its assimilation by the surrounding bone after the fracture has united. Another example of hypertrophy after long-continued tension is seen



FIG. 4-A

FIG. 4-B

Roentgenogram and schema of ununited fracture of tibia, where fibula was bolted to tibia by means of several bone-graft pegs. Body weight is transmitted through bone grafts to the fibula, which replaces the tibia. Bone graft A is under tension, but does not atrophy. The fibula is under greater pressure than before operation and responds by hypertrophy.

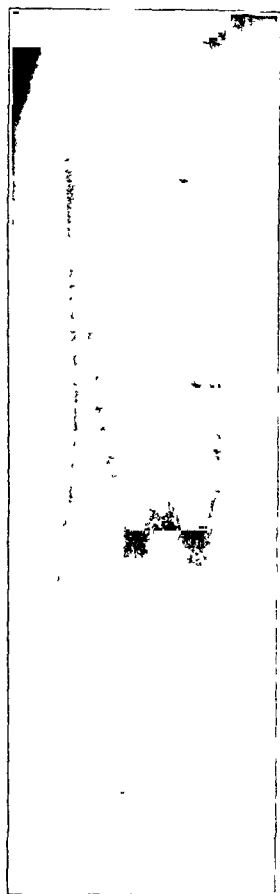


FIG. 5

Callus formation under extreme tension, as obtained in the femur-lengthening operation, before weight-bearing was permitted.

by Abbott<sup>1</sup> and Orr (reported by Alcorn<sup>4</sup> and Teal<sup>16</sup>) callus formation proceeds during the process of elongation of the limb. When consolidation occurs and weight-bearing is permitted, tension on the callus is replaced by pressure. However, the point is made that extreme tension, *per se*, does not inhibit callus formation (Fig. 5).

#### DISCUSSION

Many other examples of bone formation proceeding in the presence of tension may be cited, but the writer has referred to those instances where only a tension stress was exerted upon tissue exhibiting active osteogenesis and where pressure could be eliminated as a potent factor in this process.

Tension is by no means regarded as a more favorable environment for a bone graft than pressure. Remarkable hypertrophy of the graft occurs and "depends upon the need for it", as J. B. Murphy<sup>11</sup> expressed it in

in Figure 3, which was taken twenty-one years after the fusion operation for tuberculosis of the lumbosacral vertebrae. It is interesting to note that the graft enlarged considerably at the point of greatest stress,—namely, the junction of the movable portion with the fixed portion of the spine. When the body weight is inclined forward, a severe strain is thrown upon the graft, which must be of adequate dimensions. However, in the erect posture, the graft in this case no doubt transmits the superincumbent body weight, so that both tension and pressure enter into the question here.<sup>3</sup>

Figure 4-A is a roentgenogram taken three years after operation for ununited fracture of the tibia. Bony union of the tibia to the fibula was induced by means of several bone-graft pegs, because the extensive scar tissue over the fracture site and sclerosis of the bones, due to the original infection, interfered with the attempt to obtain union by the usual methods. This is an interesting example of the application of Wolff's law. The body weight is now supported by the fibula, and, as a result, it has increased in size in response to the increase in pressure. The proximal bone graft, A, which is under tension only, has not only retained its vitality, but it has also hypertrophied proportionately.

In the operation of leg-lengthening, where a Z-shaped osteotomy is performed and the bone ends are distracted by turnbuckles, as described

referring to bone growth, and the greatest need is seen when the pressure exerted by the body weight calls for an adequate supporting structure. Therefore, pressure is no doubt the most effective mechanical agent for altering the structure of bones. Tension requires a greater effort on the part of the osteoblasts, but it is not necessarily antagonistic to them. Bone grafts, when placed under tension, will survive if an adequate technique is followed, but it should be emphasized that fracture, atrophy, or deformity will result if the tension or pressure acting upon bone exceeds its physiological mechanical capacity.

However, it should be noted that the most favorable environment for a bone graft immediately following the operation is that of absolute immobility. When the blood supply to the graft has been established and the deposition of the callus has advanced to a point where the graft becomes firmly embedded in the host tissues, as determined by roentgenographic and clinical study, then its mechanical function may be permitted with the assurance that it will continue to enlarge until the need for it has been satisfied.

Albee<sup>2</sup> has stated that a real understanding of the *modus operandi* and theory of Wolff's law is imperative. The influence of this law upon the success of transplantation procedures of all kinds cannot be too strongly emphasized. It not only influences the graft to proliferate and to strengthen to an almost unlimited degree, if the new mechanical environment of the graft requires it, but the action of this law also causes the bone from which the graft was removed to be returned to its original strength.

#### SUMMARY

1. Clinical evidence in support of Wolff's law as originally propounded has been cited.
2. Jansen's contention that tension always produces bone atrophy is not substantiated, and his proposal that Wolff's law be modified accordingly is unwarranted.
3. A bone graft will survive and will continue to hypertrophy, although under constant tension.

The author wishes to express his appreciation to Dr. H. Winnett Orr for his helpful criticism and to Dr. Fred H. Albee for permission to reproduce the roentgenograms which accompany the article.

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# FRACTURES OF THE RIBS

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The paucity of literature on fractures of the ribs in the past ten years is readily explained by the frequency of the fractures and the relative infrequency of complications. In the suburban hospitals, near main arteries of travel, the percentage of severe cases is somewhat greater than in the large city hospitals, and this paper is based upon a large suburban experience.

We are all more or less familiar with the following practical points:

1. The fifth to the ninth ribs bear the brunt of the trauma.
2. Indirect violence, in approximating the ends of the ribs, increases their curvature—resulting in fractures outward near the middle of the rib or in front of the angle—usually involves more than one rib, and rarely produces complications.
3. Direct violence produces a fracture of one or more ribs at the point of impact, the traumatizing force thereby tending to cause sharp rib fragments to protrude into the pleura and lung with attending complications.
4. Muscle violence as a rule breaks the rib anteriorly and subperiosteally, and the seventh to the eleventh ribs suffer most frequently.
5. Single fractures are end to end; multiple fractures may overlap.
6. In multiple fractures the patient's attitude is with the body bent and the head inclined toward the affected side to reduce motion, or with the hand held over the affected side.

Our series of 279 cases consists only of patients who were hospitalized and, therefore, shows a higher percentage of patients with complications and associated injuries than if both ambulatory and house patients were included. It should be borne in mind in considering the following statistics that several factors make absolute accuracy impossible. Hospital records in general are less detailed about chest injuries, it would seem, than about injuries to other parts of the body, so that the notation "multiple fractured ribs" is not uncommon, particularly in cases where the

TABLE I  
LIST OF CAUSES OF FRACTURE

Being Hit by Moving Vehicle (Cases)	Collision (Cases)	Falls (Cases)	Falling Objects, Cave-Ins, Etc. (Cases)	Being Kicked (Cases)	Sports (Cases)	Coughing (Cases)	Total (Cases)
90	122	51	8	5	2	1	279

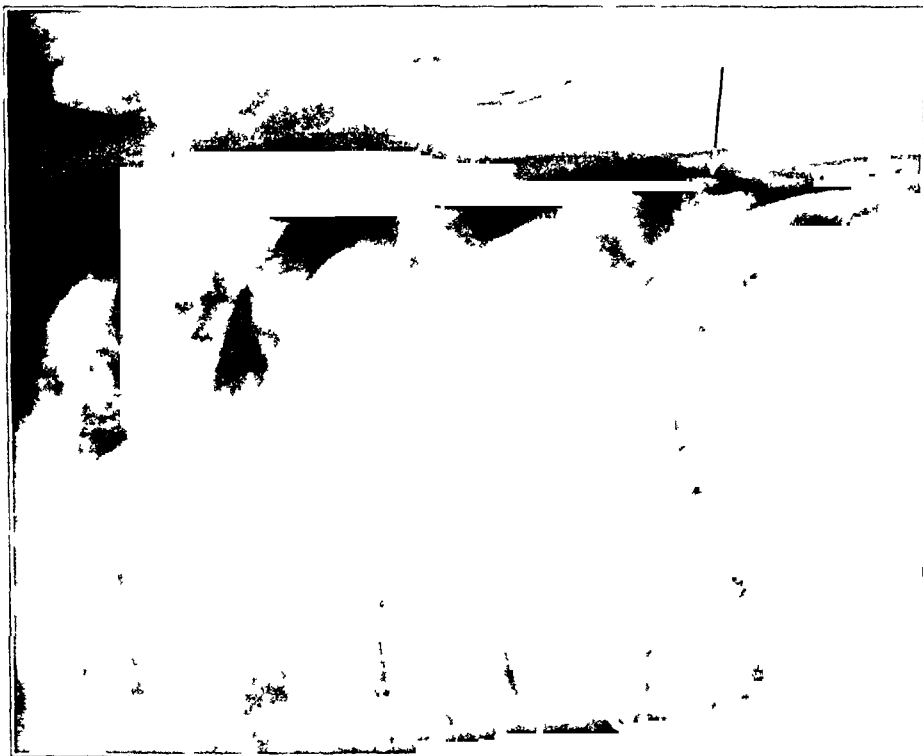


FIG. 2

Roentgenogram taken from the right oblique position. Fracture of the ninth rib is visible on close inspection. Fracture of the tenth rib is not seen.

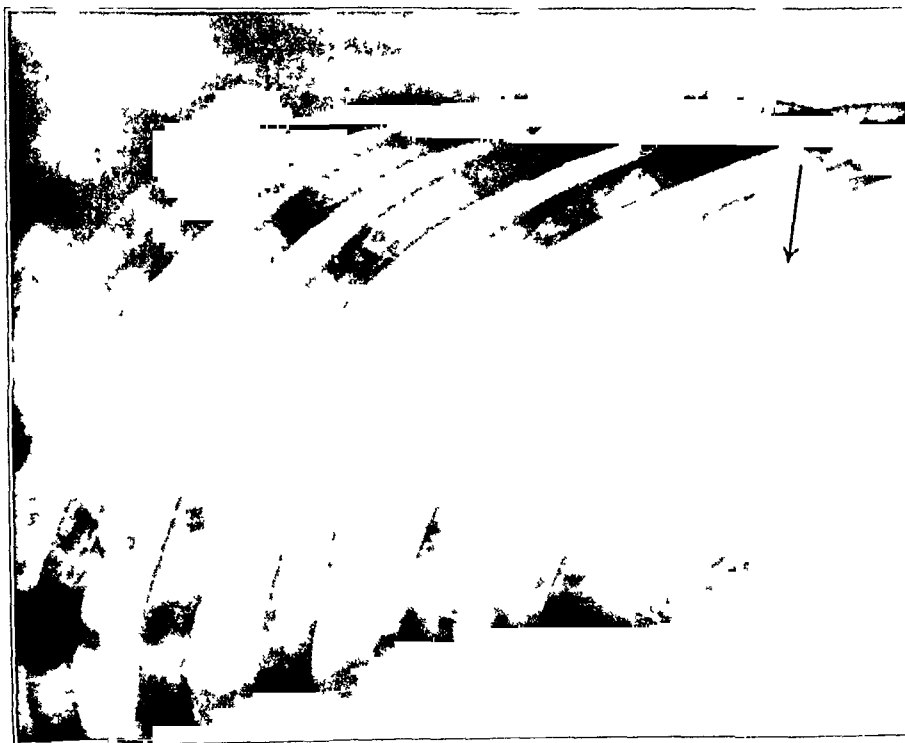


FIG. 1

Roentgenogram taken from the central position. Fracture of the ninth rib is shown. Fracture of the tenth rib is not seen.

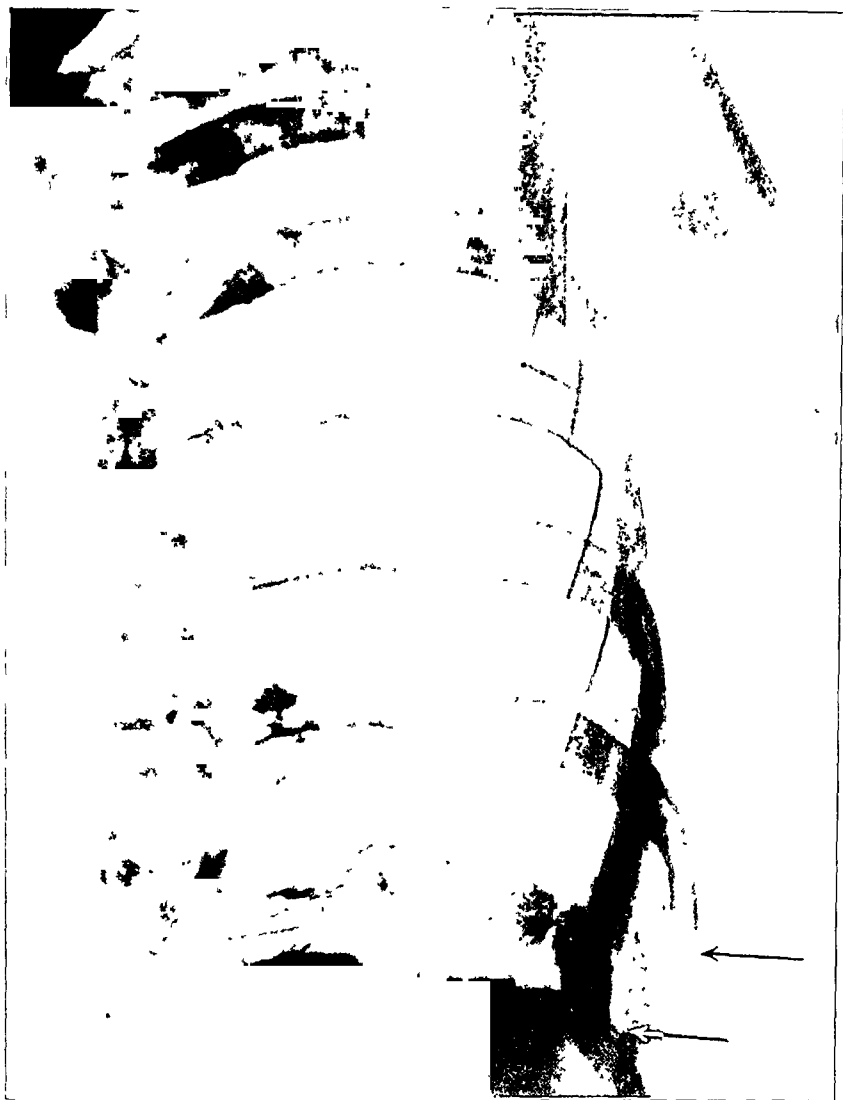


FIG. 3

Roentgenogram taken from the left oblique position. The fractures of the ninth and tenth ribs are clearly demonstrated by the separation of the fragments.

patients died shortly after admission before roentgenograms could be taken. Also, some rib fractures are exceedingly difficult to demonstrate even by roentgen-ray. It is for this reason that in all suspected cases of rib fracture roentgenograms are taken from three positions,—central, right oblique, and left oblique. This is well illustrated by Figures 1, 2, and 3, and for the use of this case the authors are indebted to Dr. Paul A. Bishop, roentgenologist.

The causes of rib fractures in this series are listed in Table I. It is immediately apparent that the automobile was responsible for more than three times as many of these injuries as all other factors combined.



TABLE II  
AGE AND SEX INCIDENCE

Age (Years)	Males (Cases)	Females (Cases)	Total (Cases)
0-10	7	5	12
11-20	9	2	11
21-30	11	14	25
31-40	44	9	53
41-50	36	15	51
51-60	49	21	70
61-70	22	12	34
71-80	11	6	17
81-90	1	0	1
Total	190	84	274*

\* In 5 cases age or sex was not listed on chart.

Table II demonstrates that males suffer rib fractures about two and one-quarter times as frequently as females, as would be expected, and that most fractures occur between the ages of thirty and sixty years. Fractures seldom occur in children, unless the chest is crushed.

Table III illustrates that the fifth to the ninth ribs are the ones most frequently fractured. The first and second ribs are well protected by the clavicle and are seldom fractured; most of the cases recorded in the literature have resulted from muscle action such as in coughing and sneezing. Similarly, the eleventh and twelfth ribs, being attached at only one end, tend to give way with the force of impact.

#### SYMPTOMATOLOGY

The symptoms and signs of the uncomplicated case are so well known that they need be mentioned only briefly. There is usually a history of an injury, followed by a severe, sharp pain in the chest, which is made worse by deep inspiration. A localized point of tenderness over the

TABLE III  
FREQUENCY OF FRACTURE OF INDIVIDUAL RIBS

No. of Rib	1	2	3	4	5	6	7	8	9	10	11	12	Total
Right Side	14	21	26	32	36	42	53	53	42	38	28	8	393
Left Side	8	25	29	38	48	49	51	47	42	39	27	11	414

TABLE IV  
COMPLICATIONS \*

	No. of Cases
Hemothorax . . . . .	39
Subcutaneous emphysema . . . . .	32
Pneumothorax . . . . .	18
Lacerated lung . . . . .	17
Bronchopneumonia . . . . .	10
Traumatic asphyxia . . . . .	2
Pulmonary oedema . . . . .	1
Mediastinal emphysema . . . . .	1
Atelectasis . . . . .	1
Pleurisy (severe) . . . . .	1
Total . . . . .	122

\* 122 complications in 83 patients, representing 29.7 per cent. of all patients, of whom 29 or 10.4 per cent. died.

fracture site is present, and at times crepitus may be felt. Roentgenograms reveal the fracture in most instances. In case of doubt, the diagnosis is made on the clinical evidence, negative roentgenograms notwithstanding. Our cases have all been confirmed by roentgen-ray.

#### TREATMENT

The treatment of the simple cases consists usually in adhesive strapping, applied in expiration from below upward, and extending from the sound side anteriorly to the sound side posteriorly. Straps should never be applied over the epigastrium, since this region moves with respiration and its motion will thus be transmitted to the chest. Strapping is not advisable over abraded skin, or in pneumonia, or when respiration is embarrassed from pneumothorax or other causes, or when its use would aggravate pain or deformity. Other methods occasionally used are complete binders, corsets, and the "Sam Browne" plaster belt (Waugh). This latter consists of four-inch strips of plaster-of-Paris, applied to the lower chest in expiration, with a communicating strip running over one shoulder. The belt need not be thick; six or seven turns of plaster bandage will suffice. It is usually advisable to keep the chest immobilized for about four weeks. Sedatives should be used where indicated.

#### COMPLICATIONS OF RIB FRACTURES

Many of the complications are so rare as to be worthy of only passing comment. Pericardial and cardiac injury, diaphragmatic hernia, and rupture of the liver, spleen, or colon are major catastrophes which deserve surgical intervention, with the rib fractures as a minor consideration. Compound fracture through the skin may require débridement and, perhaps, antisepsis and care to minimize the development of osteomyelitis.

Pyothorax, excessive callus, and intercostal neuralgia as late complications may require secondary operation. Congestion and oedema of the lungs, bronchitis, pleurisy, pneumonia, and direct or contralateral collapse of the lung are primarily the concern of the internist. Simple pleural injury gives the signs of localized pleurisy and requires no special treatment. Traumatic asphyxia is produced by severe compression of the chest, and is due to an intense passive congestion. There is a dusky cyanosis, confined to the head, neck, and upper chest, often accompanied by subconjunctival hemorrhage, or petechiae. It is alarming but usually not serious, clearing up entirely in from three to five days. Two patients in this series showed it.

Table IV demonstrates the complications encountered in our series, and it will be noted that hemothorax, subcutaneous emphysema, and pneumothorax are the most frequent, in the order named.

Here again we would like to call attention to the fact that in some instances reference to complications in the patient's record was vague and inconclusive, and positive statements were made in the main only when the complications were revealed by roentgenograms. In other cases where the injuries proved almost immediately fatal, terms such as "internal injuries" were used to replace definite findings. Of the 279 patients in this series, eighty-three or 29.7 per cent. had one or more of the complications listed in Table IV, and twenty-nine or 10.4 per cent. died. It will be recalled that this series does not include ambulatory cases of fractured ribs, which ordinarily would have no complications.

Injury to the lung may occur without laceration of the parietal pleura,—that is, the lung may be burst by compression. Hemoptysis as the sole symptom may mean pulmonary contusion, but, associated with hemothorax, hemopneumothorax, or the parietal escape of air, it implies more serious lung injury.

Hemothorax, in addition to being the most common complication in this series, is also one of the most serious. If of pulmonary origin, it is rarely of sufficient volume to require intervention,—that is, aspiration, induced pneumothorax, or surgery. If there is reason to believe that there is an open intercostal or internal mammary vessel or a large pulmonary vessel, an operative procedure is indicated, of course, but it is common experience that, when blood and air collect within the pleural cavity in sufficient quantity to compress the lacerated lung, bleeding will usually be controlled. As stated by Findlay, the blood and air act as a splint to the injured lung and tend to immobilize the entire side of the chest. In treating these cases it is our policy, therefore, not to aspirate unless considerable respiratory embarrassment occurs. Development of empyema later may require surgical intervention. Rapid hemorrhage from the intercostal or internal mammary arteries into the pleural cavity may, however, exsanguinate the patient or seriously embarrass cardiac and pulmonary function. Ligation of these vessels, aided by rib resection, may be necessary. It is of interest to note that Kellogg Speed quotes

Schütte as giving a 40 to 60 per cent. mortality in intrathoracic hemorrhage. Many mild cases of hemothorax are undiagnosed by physical examination and do not show in the roentgenograms.

In subcutaneous and intermuscular emphysema there is a tear in the parietal pleura, which allows air to escape from the pleural cavity, to some extent acts as a safety valve, and quite probably in some cases saves the patient from an otherwise certain death. It has even been said that the development of such emphysema is of good prognostic import. Local pressure and strapping usually suffice to control subcutaneous emphysema, although in extensive cases Money has employed aspiration of the chest with incisions below each clavicle, and Goodliffe suggests the use of a medium-sized cannula, producing partial collapse of the lung. He removes the cannula in twelve hours. Multiple incision has likewise been used by early writers.

Mediastinal emphysema, however, is more insidious, is concealed, often goes unrecognized, and death is ascribed to that too-loose term, "internal injuries". As the pulmonary tear which causes it is usually a ragged one, there is a tendency for the tear to have a valvular action, and, as the thoracic wall rises in inspiration, air is sucked out of the lung into the pleural cavity, and, as the thoracic wall drops in expiration, the air in the pleural cavity squeezes the tear shut. Therefore, each inspiration causes a further increase in the pneumothorax and, when finally the intrapleural pressure reaches approximately the neutral point or zero, a forced expiration causes a forcing of air from the opposite lung across the bifurcation of the trachea into the injured lung and out through the tear into the pleural cavity. In this way the intrapleural pressure may be raised considerably above zero. As the pneumothorax increases, the intrapleural pressure rises; the mediastinum is proportionately pushed toward the uninjured side, and, the farther over it moves, the more the uninjured lung becomes compressed until finally the whole pulmonary mechanism is unable to maintain an adequate tidal-air exchange, and the patient suffocates. This condition is called tension pneumothorax.

Ballou and Francis, in investigating the consequences of variations in mediastinal pressure, found that air could travel great distances and take several courses, for example:

1. Under fascia, costal pleura, and intrathoracic fascia;
2. To the hilum of the lung and into the mediastinum and even over the entire body (the most severe type);
3. Along the trachea to the floor of the mouth and under the tongue;
4. Along the sheaths of blood vessels, even dangerously compressing the axillary and femoral vessels;
5. Retroperitoneally, along renal vessels to the kidney.

It is obvious that air contained within the pleural cavity above a normal manometric level will seek an exit through any possible channel, and, if the traumatic concussion has caused some tearing in the mediastinal pleura as, for example, near the hilum of the lung, the air will work its way into

the areolar tissue of the mediastinum with the characteristic roentgenographic picture. Under such circumstances air may soon be palpable in the lower throat, and Tiegel has advised making an incision there through the superficial layer of the deep cervical fascia and placing a suction cup over the incision to extract the air, or at least to decompress the mediastinum. Even though no tear may exist in the mediastinal pleura, air may enter the mediastinum through the pleural tear in the periphery of the lung, passing through the pulmonary interstitial tissue and through the hilum of the lung into the mediastinum. Baskin has called attention to the importance of coughing, which closes the glottis and forces in more air.

The effects of mediastinal emphysema are:

1. Stagnation of blood in the lungs;
2. A fall in blood pressure;
3. Pulmonary oedema;
4. Pericardial effusion;
5. Diminished heart action;
6. Oedema of the tracheobronchial mucous membrane;
7. Pulmonary emphysema.

Once mediastinal emphysema has become very extensive, and to it are added the usual shock and hemorrhage, it is almost too late for treatment. The danger should be recognized early and treatment instituted to prevent extensive mediastinal emphysema,—that is, to prevent the high-tension pneumothorax which precedes it. Keeping this down will also prevent suffocation through compression of the uninjured lung. When either the roentgenogram or the displacement of the heart indicates that there is a pneumothorax present, a needle should be introduced into the traumatic pneumothorax space with a regular pneumothorax apparatus, and the manometric pressures should be determined. If these are abnormal, or if either the roentgenogram or the position of the heart shows that there is extensive pneumothorax, this air should be aspirated by reversing the direction of the flow in the bottles of the pneumothorax machine. As much air is aspirated as may be necessary to reestablish some such negative intrapleural pressure as minus 7 to minus 9. This usually brings the heart back to normal position. Then the patient is watched with extreme and constant care for signs of a recurrence of the pneumothorax. This is very likely to happen, as the wound in the lung is probably still open. Should signs of recurrence develop, the procedure described may be repeated.

If it should be necessary to repeat this more often than every half hour or so, or over a long period of time, it is more effective and safer for the patient if one provides for constant egress of the air that keeps coming into the pleural cavity. Rather than introducing a catheter, which after all exposes the pleural cavity to a greater chance of infection than if only a needle were used, one should insert a short needle, the bevel of which has been filed down so that it is fairly blunt but still sharp enough to

penetrate the thoracic wall. To the needle should be attached a long rubber tube, which is introduced beneath sterile water in a sterile bottle, placed either on the floor or at a level beneath that of the patient. This needle and tube system provides "water-seal drainage" of the air, and, whenever the pneumothorax pressure becomes sufficiently high, it readily escapes through the needle and tube and bubbles out through the water, which, in turn, prevents aspiration of air into the chest.

On rare occasions, it is advisable to do a thoracotomy to relieve tension, as advocated by Lilienthal and others, or to perform a wide intercostal thoracotomy in order to sew up a pulmonary tear, which all evidence indicates is a very extensive one. Actually, thoracic surgeons are very conservative about operating in the majority of cases of severe thoracic trauma.

If, to the measures just advanced, one adds prompt treatment of shock, the use of an oxygen tent, and, in selected cases of crushed chests, the application of hook traction to the sternum as advocated by Jones and Richardson, it is certain that many borderline cases will be saved.

*Technique:* Under local anaesthesia, two incisions, one centimeter long, are made just lateral and at right angles to the border of the sternum at the level of the third interspace, exposing the edges of the sternum. The sternum is grasped with cervical forceps. Hooks are inserted, and the forceps are locked. Weights and pulleys, attached to a rainbow frame, are used to maintain traction. This is a dangerous procedure, because any puncture of the pleura in these desperate cases might be fatal. This could occur either at the time of application of the hooks or from some slip of the forceps. In an emergency, the skin and subcutaneous tissues could be grasped until the shock period was over. Traction on the sternum is suggested only as a means of combating anoxaemia due to crushing injuries of the chest, which cause increased mobility of the chest wall. Secondly, through reduction of the anoxaemia, diminution of the muscle effort necessary for respiration, and aiding venous return to the heart by increasing the negative pressure in the great intrathoracic veins, the degree of shock may be lessened. Although correction of the deformity may be obtained in this way, traction is not suggested for this purpose and should be abandoned as soon as pulmonary ventilation becomes sufficient. The considerable deformity present at first may be of no permanent importance. The possibility of pneumothorax makes this procedure risky.

Hernia of the lung has been noted occasionally, always with fracture of several adjacent ribs, the fragments being so displaced upward and downward as to leave a gap through which the lung protrudes. Invagination and rib transplantation across the invaded intercostal space are recommended for this.

The most important and perplexing abdominal complication is ileus. This symptom usually develops twenty-four hours or more after the injury and raises the question of an intra-abdominal associated lesion. It

TABLE V  
ASSOCIATED INJURIES

Injuries	No. of Cases
Cerebral concussion . . . . .	35
Renal contusion . . . . .	4
Ruptured spleen . . . . .	2
Burns . . . . .	2
Cerebral hemorrhage . . . . .	1
Dislocated thumb . . . . .	1
Dislocated knee . . . . .	1
Dislocated shoulder . . . . .	1
Ruptured intestine . . . . .	1
Fractures (other bones) . . . . .	173
Clavicle . . . . .	36
Tibia . . . . .	19
Skull . . . . .	16
Fibula . . . . .	16
Humerus . . . . .	13
Pelvis . . . . .	13
Vertebra . . . . .	12
Radius . . . . .	9
Nose . . . . .	9
Ulna . . . . .	6
Scapula . . . . .	6
Femur . . . . .	5
Sternum . . . . .	3
Hum . . . . .	2
Tarsals . . . . .	2
Metatarsals . . . . .	1
Carpals . . . . .	1
Maxilla . . . . .	1
Mandible . . . . .	1
Patella . . . . .	1
Os calcis . . . . .	1

TABLE VI  
ANALYSIS OF DEATHS

Cause of Death	Days after Injury								Total
	1	2	3	6	10	12	17	22	
Multiple injuries	7	4	1			1	1		14
Fracture of skull	5		1						6
Ruptured spleen		1		1					2
Bronchopneumonia			2						2
Ruptured intestine			1						1
Myocardial failure			1						1
Mediastinal emphysema					1				1
Pulmonary oedema	1								1
Lung abscess								1	1
Total	13	5	6	1	1	1	1	1	29

alone has been severe enough to cause death with autopsy findings negative except for the fractured ribs. Adams reported two cases; Ralphs and Christopher each described single cases with the preoperative diagnosis of intestinal obstruction; and Vandell recorded a case under the diagnosis of mesenteric thrombosis, perforation of the intestine, and rupture of the diaphragm. Two of these cases resulted fatally. Naz's case was caused by compression of the celiac plexus by a post-traumatic hematoma, but the autopsy also showed emphysema along the left side of the vertebral column, infiltrating the sympathetics. Irritation of the great splanchnic nerve, which arises from the sixth to the tenth thoracic ganglia near the head of the ribs, is the generally ascribed cause of this condition. Since any retention of gas or faeces favors ileus, attention to bowel stasis is *imperative* in the treatment of rib fractures. Prostigmin and spinal anaesthesia have their advocates.

#### ASSOCIATED INJURIES

Table V is an analysis of the injuries associated with the fractures of the ribs. It will be noted that cerebral concussion is the most common serious injury, while the clavicle is the bone most frequently fractured.

Table VI gives in a rough way an analysis of the cause of death in the twenty-nine fatal cases.

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# AN OPERATIVE PROCEDURE FOR THE TREATMENT OF HAMMER-TOE AND CLAW-TOE

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Having from time to time experienced considerable difficulty in obtaining a good result from the Higgs or the Jones operation for hammer-toe, the author was led to devise an operative procedure, which has proved to be both simple to perform and uniformly successful as regards results.

In order to obtain a successful result from an operation on a hammer toe, it is necessary that:

1. The flexion contracture of the proximal interphalangeal joint be overcome. This can be done by an arthrodesis of this joint in good position.

2. The fixation of the arthrodesed bones be maintained until bony union has occurred.

3. The toe be plantar flexed at the metatarsophalangeal joint. This position can be obtained by tenotomizing the taut distended tendons and by maintaining the toe in the plantar-flexed position by means of adhesive strapping for three weeks.

Considerable difficulty was experienced with the Higgs operation for

hammer-toe for the following reasons: "When shaping the proximal phalanx as a spike it often crumbles and becomes shortened. Even when the spike was formed considerable difficulty was experienced in forcing the spiked end of the

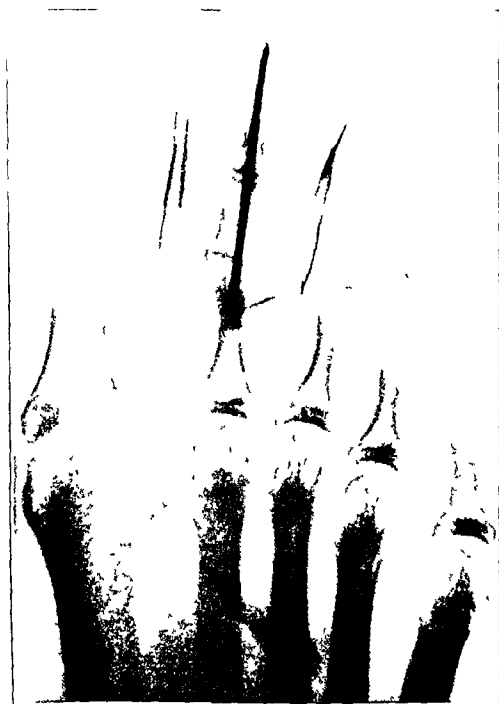


FIG. 1-A



FIG. 1-B

Dorsoplantar and lateral views, showing Kirschner wire in position.

proximal phalanx into the base of the second phalanx, as it became fragmented. In this way the arthrodesed surfaces came into very unstable apposition. Moreover the toe becomes considerably shortened, thus pre-disposing to or aggravating hallux valgus if it already exists."

The objection to the Jones operation is that it is difficult to maintain the two arthrodesed ends of the phalanges in good position, until union has taken place.

The following operative procedure was devised to obviate these objections,—that is, to prevent shortening of the toe, to immobilize the arthrodesed ends of the bone, to maintain the arthrodesed ends in position until bony union has occurred, and to maintain the whole toe in good position until the deformity is overcome.

Under general or local anaesthesia, the usual dorsal elliptical or, preferably, longitudinal incision is made. The dorsal expansion of the extensor tendons is exposed and divided longitudinally over the proximal interphalangeal joint. The divided edges are held aside, and the proximal interphalangeal-joint surfaces are arthrodesed with a narrow chisel. As little bone as possible is removed. All the cartilage should be carefully excised. The toe is then straightened into a position almost vertical to the dorsum of the foot. It will be found that in this position the toe becomes straight, the plantar-flexed distal part of the toe having been dorsiflexed into alignment with the dorsiflexed proximal portion of the toe. A thin Kirschner wire is then introduced into the long axis of the toe, and the three phalanges are threaded along the Kirschner wire, like a row of beads along a piece of wire. The direction taken by the wire can be easily controlled by opening up the arthrodesed joint when the point of the wire appears on the arthrodesed surface of the second phalanx. By previous measurement of the wire against the toe, excessive penetration of the wire into the head of the metatarsal can be prevented. The phalanges having been fixed by the Kirschner wire, the wound is closed by a few silkworm-gut sutures. It will be found that the Kirschner wire holds the toe as rigid as a rod. The long and short extensors of the toe are then tenotomized. The straightened toe can be easily plantar flexed at the metatarsophalangeal joint and held in this position by means of adhesive strapping. The wire is cut off almost flush with the distal end of the toe, about one-eighth of an inch being left projecting. The projecting end is then surrounded by some gauze dressing. This immobilization is continued for three weeks, at the end of which the wire and strapping are removed. The patient can walk in three days.

The author has used this operative procedure in at least twelve cases during the last eighteen months, and so far the results are excellent.

The author is greatly indebted to his chief, Mr. F. W. Holdsworth, for allowing him both to carry out this work and to publish this report.

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# PSEUDOFRACTURES

## A MANIFESTATION OF NON-SUPPURATIVE OSTEOMYELITIS

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Roberts and Vogt<sup>1</sup> have recently reported twelve cases of a new clinical entity to which they have given the name of pseudofracture of the tibia. This condition is described as a lesion always occurring in the upper third of one or both tibiae and characterized in the roentgenogram by a localized area of periosteal thickening and new-bone formation over what appears to be an incomplete V-shaped fracture of the cortex. The patients were children from four to sixteen years of age, with no significant history of injury, but with a history of some type of previous infection in three instances. The symptoms consisted of mild to moderate pain and tenderness, and healing tended to be spontaneous.

The following three cases observed by the authors illustrate that this condition is not confined to children and that bones other than the tibia may be affected, and add some evidence as to the etiology.

CASE 1. A boy, twelve years of age, was admitted to the Hospital on February 28, 1936. In the fall of 1933, he had sustained a fall in which the right knee was injured.

A "carbuncle" immediately developed on the injured knee, and the patient was confined to bed for five weeks. Complete recovery ensued. In the fall of 1934, the boy had been active in athletics, and a "Charley-horse" developed below the right knee. He was "treated" by his coach and apparently recovered. In the fall of 1935, the patient's father had noticed the boy limping, and inquiry elicited the fact that pain and soreness were present below the right knee. These symptoms persisted in varying degree, and were present when the patient was admitted to the Hospital, but they had never been so severe as to cause him to remain in bed.

Physical examination revealed a tender area just below the right tibial tubercle, apparently with some enlargement and roughening of the tibia in this area. The patient's temperature rose to between 99 and 100 degrees Fahrenheit each afternoon.



FIG. 1-A

Case 1. Right tibia before operation.

The laboratory reported that the Wassermann and Kahn tests were negative. The leukocyte count was 7,800; the erythrocyte count was 5,200,000; and the hemoglobin was 80 per cent. The titer of staphylococcus antitoxin was zero.

The roentgenologist made the following report: "Approximately four inches below the upper epiphyseal line of the right tibia we see a zone of sclerosis extending transversely across the shaft. On all sides of the tibia adjacent to this zone there is heavy periosteal new bone. We are aware of the patient's history. Regardless of this, roentgenographically, the picture is that of an incomplete fracture which has healed." (See Figure 1-A.)

An exploratory operation was done on March 3, 1936. A section of bone was removed from the affected area. No pus was encountered. Cultures were taken from the bone marrow, but failed to produce a growth.

The pathologist reported: "Histological section shows irregular trabeculae of bone which are comparatively normal. The bone marrow shows fibrillar connective tissue, and mononuclear leukocytes are scattered throughout. In some places the bone tissue is hyperplastic. Diagnosis: Chronic osteomyelitis."

The wound healed *per primam*, and the patient was dismissed on March 7, 1936. On December 5, 1936, he returned to the Hospital. He had had no symptoms in the right leg since leaving the Hospital, but for four weeks he had had pain in the upper left tibia.

The laboratory report was essentially the same as on the first admission.

The roentgenologist reported: "The upper left tibia shows an area of bone absorption, poorly circumscribed, showing on its superior aspect a moth-eaten area, with extensive adjacent periostitis [Fig. 1-B]. The picture is definitely that of a localized infectious process. We must now consider the pathology described in the right tibia nine months ago to be of the same origin although a roentgenogram shows no residue at present."

An exploratory operation was done on December 8, 1936. An area of bone necrosis



FIG. 1-B

Case 1. Both tibiae nine months after Fig. 1-A. The left shows a beginning pseudofracture line and a small area of bone necrosis. The right is healed.

was found, but pus was not encountered. Cultures taken from the bone marrow later proved to be negative for growth.

The pathologist again made a diagnosis of chronic osteomyelitis from the histological picture.

The patient's recovery was uneventful with immediate relief from symptoms.

**CASE 2.** A man, twenty-three years old, was admitted to the Hospital on April 21, 1938. In the fall of 1933 this patient had been kicked below the left knee in a football game and had sustained a laceration. This had become infected and had drained several weeks before healing. No further difficulty had been experienced until January 1938, when the patient began to have dull pain below the left knee. Swelling and tenderness were present in this area, but the patient remained ambulatory. The symptoms had progressively subsided for one month previous to admission.

The laboratory reported that the Wassermann and Kahn tests were negative. The leukocyte count was 7,100; the erythrocyte count was 4,850,000; and the hemoglobin was 82 per cent. The titer of staphylococcus antitoxin was zero.

The roentgenologist reported: "We demonstrate what is considered to be the residue of an old fracture in the upper third of the tibia. There is bone proliferation along a barely discernible fracture line and cortical new-bone formation on the posterior aspect of the tibia in the area of the fracture, which has healed perfectly." (See Figure 2.)

Since this patient's symptoms were subsiding, he was dismissed. Six months later he reported that he had been symptom-free for three months.

**CASE 3.** A male, twenty-two years old, a college student, was seen as an out-patient on December 12, 1938. He complained of pain and tenderness over the right lateral malleolus of two weeks' duration from no known cause. This patient was a candidate for the track team and had been running regularly all fall.

Examination showed swelling and tenderness over the right lateral malleolus. A

roentgenogram (Fig. 3-A) was reported as negative.

Hot packs were applied to the ankle, with little relief. The patient continued in school, but ceased track work. A second roentgenogram (Fig. 3-B) was taken on January 20, 1939, and the roentgenologist reported as follows: "There is evidence of an old fracture approximately three centimeters from the lower end of the right fibula, which has healed with excess callus. A previous plate was reported negative for injury. In looking back at the old plate we still cannot discern a fracture line."

The patient remained ambulatory, and symptoms entirely subsided about April 1, 1939. On May 15, 1939, the patient



FIG. 2

Case 2. Left tibia, showing a barely discernible fracture line and cortical new-bone formation.



FIG 3-A

Case 3 Right ankle on December 13, 1938, two weeks after first complaint. This roentgenogram was reported as negative.



FIG 3-B

Case 3 Right ankle on January 20, 1939, showing pseudofracture of lower fibula.

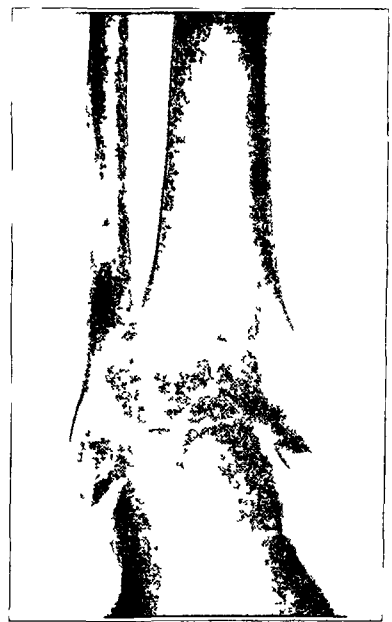


FIG 3-C

Case 3. Right ankle on March 7, 1939.



FIG. 3-D

Case 3. Left knee on May 15, 1939, showing pseudofracture of upper fibula.



FIG. 3-E

Case 3. Roentgenograms on May 31, 1939.  
*Right ankle:* Healed pseudofracture of lower fibula.  
*Left knee:* Pseudofracture of upper fibula.

again reported with pain over the head of the left fibula of one month's duration. Oedema and tenderness were present over this area. Roentgenograms (Fig. 3-D) were taken, and the report was as follows: "There is periostitis with a pseudo fracture line, indicative of a peculiar type of osteomyelitis at the upper end of the left fibula. This is undoubtedly the same type of pathology previously described in the lower end of the other fibula."

This patient gave no history of infection with the exception of frequent attacks of sore throat and the "flu".

Since the history, physical findings, and progress of these interesting lesions in no way conflict with a definite histological picture of infection, the authors are personally convinced that the so-called pseudofractures of Roberts and Vogt are a type of non-suppurative osteomyelitis. The roentgenogram of the second lesion in Case 1 also lends credence to this view.

A causative organism was not found. However, the fact that in two of these cases no staphylococcus antitoxin was found in the blood is some evidence, but not proof, that the staphylococcus is not at fault.

The authors' very limited experience would indicate that decompression of the affected bone promotes more rapid healing and prompt alleviation of symptoms.

1. ROBERTS, S. M., AND VOGT, E. C.: Pseudofracture of the Tibia. *J. Bone and Joint Surg.*, XXI, 891, Oct. 1939.



## A METHOD OF FIXATION FOR FRACTURE OF THE CLAVICLE<sup>1</sup>

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The numerous methods of fixation for fracture of the clavicle have been ineffective in our hands in many cases. Most of the methods described will hold a fractured clavicle in moderately good position when the splints or supports are applied tightly enough. However, the pressure necessary to hold the fragments in good position is frequently too great, with the result that the pain and discomfort are so intense that the patient either removes the bandages and supports or demands their removal. In spite of this, practically all fractures of the clavicle unite, even though the fragments are not in good anatomical position, and the functional results are good. The cosmetic and anatomical results frequently, however, are very disappointing, especially in women. Even in men, the depressed shoulder with the shortened clavicle is not a desirable end result.

Considering these points, an effort was made to improve the treatment of fracture of the clavicle. In books on anatomy it is indicated that the clavicle has a cortical shell, but its interior is not very well described. In order to learn more about this, the author divided the clavicle in longitudinal, oblique, and transverse directions and examined its structure. The cortical shell was found to be thickest at the middle third of the bone and to remain as a strong cylinder except for the medial half inch and the lateral inch. At these points, the shell became thinner, and, finally, the circumference at both ends was represented by an extremely thin plate of bone on the surface (Fig. 1). The interior of this cortical shell was filled with light cancellous bone with some lamellae running longitudinally and others crossing obliquely. These trabeculae were attached to the cortex by minute cone-shaped tubercles. The depressions between these tubercles were large enough, so that the point of a sharp instrument passing down the lumen might catch in one of them, which might prevent its passage onward. The general shape of the cortex of the bone, therefore, was a strong, moderately curved, central cylinder, which had a fairly large funnel-shaped medial end and a more flattened funnel at the lateral end.

The author was impressed with the possibility that, if a moderately flexible steel wire were started through the thin funnel-shaped cortex at either end, it might be directed into the central cylindrical part, and that this shell of bone might guide it around the curves through the length of the lumen. If this hypothesis were true, and if a fracture of the clavicle were *accurately reduced*, a wire passed in this fashion might give adequate internal fixation of the fragments. During many trials on cadavera, when a wire was passed through the thin cortex at the inner or outer end

\* Received for publication on February 29, 1940.

of the shell and directed toward the central part, it was guided by the funnel-shaped end into the central cylinder. On reaching this, it followed the curves and stayed within the cortical shell until it reached some point fairly near the opposite end. As most fractures of the clavicle with displacements occur somewhere in the central half of the bone, it was thought that this form of fixation might apply to most of them.

The question arose as to whether a thin wire that would follow the lumen would give adequate fixation of the fragments. If there was much lateral stress on the clavicle, such as might be required to hold up the shoulder, according to the current theory of the function of the clavicle, it obviously would be inadequate. Subsequent observations demonstrated that even the thinnest wire that could be passed provided sufficient fixation, and that there was little, if any, lateral stress on the wire at the fracture site, tending to bend it.

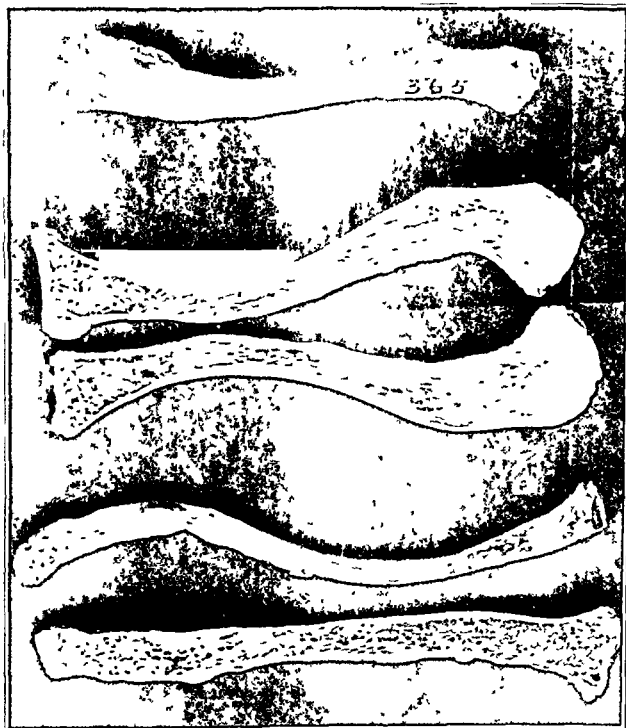


FIG. 1

Longitudinal section of the clavicle in horizontal and vertical planes, showing a thick cortical bone in the central part, which becomes thinner towards the ends. The lumen is filled with cancellous bone.

In twenty-nine cases of fracture of the clavicle, observed during the last three years, there have been only three in which the fracture was not comminuted and in which three or more fragments could not be identified. Most articles and textbook descriptions of this lesion do not mention this. In the previous methods of treating this fracture, this point has had little attention. However, when one tries to obtain perfect reduction, the presence of a third and fourth fragment frequently is quite an obstacle. In several of the author's cases a third fragment was found lying transversely between the other two, preventing accurate reduction. In one instance a moderately large third fragment was discovered pressing on the deeper surface of the skin. Under general anaesthesia it was impossible to manipulate this back into position; therefore, to prevent ulceration through the skin, open reduction was done. On this occasion the method of internal fixation to be de-

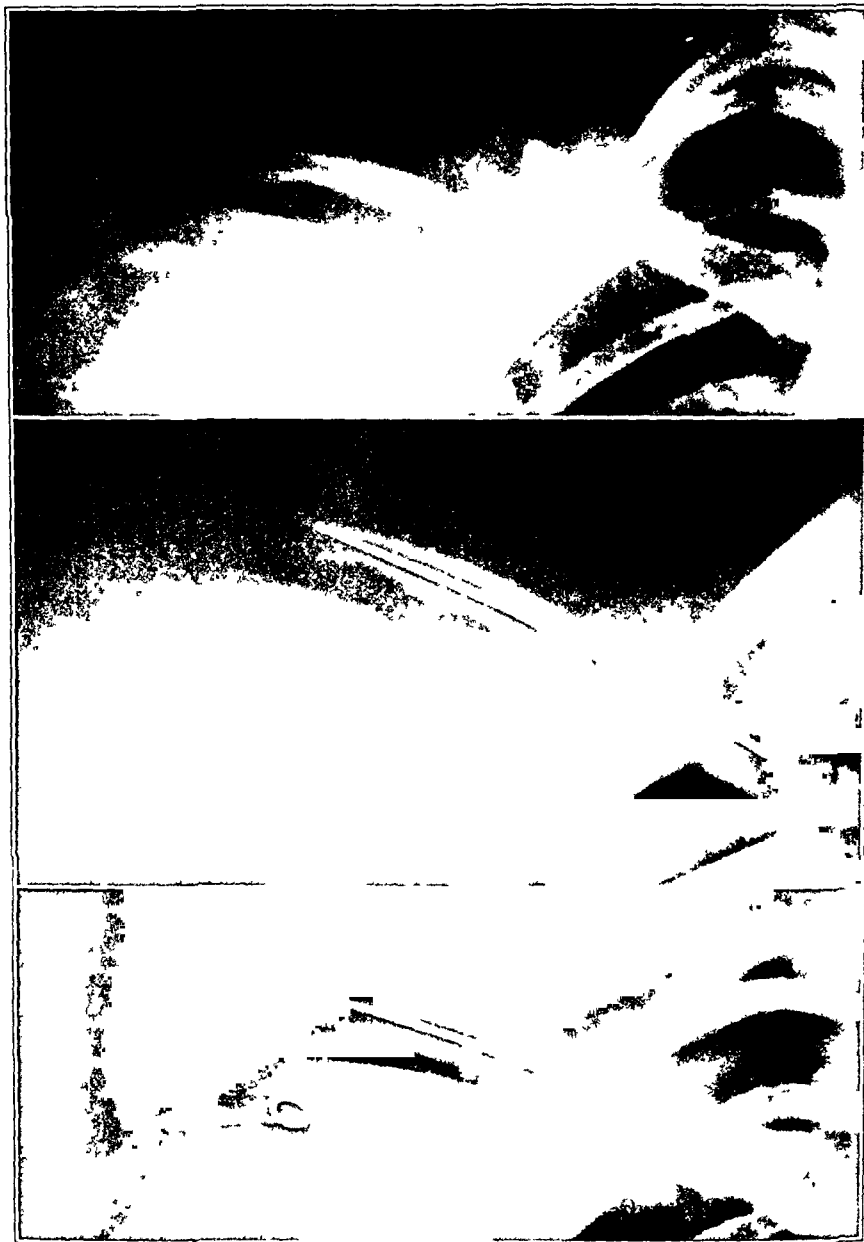


FIG 2

Roentgenograms showing comminuted fracture of the clavicle with reduction and fixation by a Kirschner wire and bony union without deformity

scribed was employed quite satisfactorily, and the third fragment was replaced in its normal position.

A few attempts at reduction have been made under local and block anaesthesia, but in most cases reduction has been done under general anaesthesia. In reducing these fractures, many obstacles have been encountered. Even with block-and-tackle traction on the arm it has been with the greatest difficulty that an accurate reduction has been obtained in some cases. A method of taking lateral roentgenograms of the clavicle has been developed; these, together with the anteroposterior

view, give better indications of the direction of the fracture, thereby enabling more intelligent manipulation. In many of the cases it has been possible to place the fragments accurately in their relationship, but in quite a number we have been able to restore only the alignment and length and have been unable to obtain perfect reduction. Special clavicle forceps with smooth surfaces are used to assist in manipulating the fragments.

The reduction is not difficult if undertaken before much swelling has occurred; later on it is much more difficult to grasp and to manipulate the fragments.

When a satisfactory reduction has been obtained, the field is prepared and a quarter-inch incision is made over the subcutaneous surface, one inch from the inner end of the clavicle. Through this, a hole, a quarter of an inch in diameter, is drilled in the thin cortex. The direction of the drill is gradually changed from the perpendicular until it points toward the central cylinder. Through this hole a medium-sized Kirschner wire is passed. If it is started in the right direction, it always traverses the central cylinder and passes across the fracture line into the distal fragment,

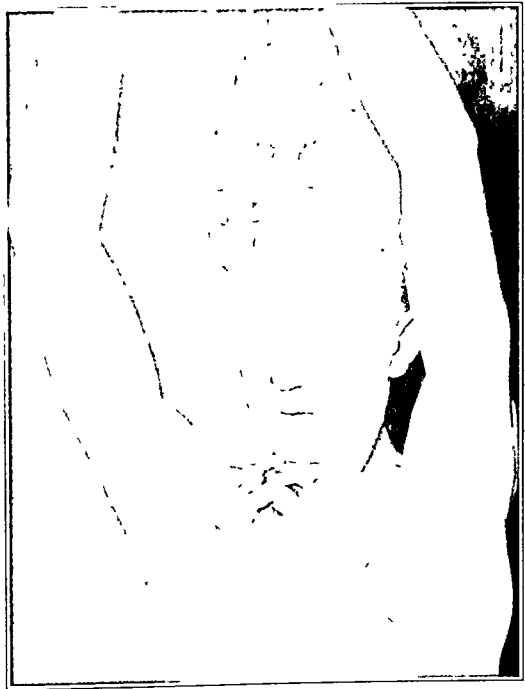


FIG. 3

Showing ability of the patient to abduct the arm without pain on the morning following fixation of the fragments by a Kirschner wire.

provided the reduction has been satisfactory. Occasionally, in the earlier cases, considerable difficulty in starting the wire in the right direction was experienced; however, with practice it has become quite easy to accomplish this. When the wire crosses the fracture line, the clavicle immediately becomes stable, and the arm, shoulder, and clavicle can be moved about quite freely without any displacement of the fragments. Under the fluoroscope, the movements of the shoulder and arm are seen to cause slight springing of the wire at the fracture line, but on no occasion has the wire failed to retain the fragments in good position. The wire is cut short to allow it to disappear beneath the skin, and a small dressing is applied over the incision. In some cases the wire has been left protruding from the skin, but, because of its oblique course through the clavicle, there has always been some pressure on the skin, causing ulceration. It was found to be better, therefore, to place the wire beneath the skin. If for some reason it is to be removed later on, this can be done through a very small incision under local anaesthesia. This has been done without

difficulty on several occasions when the wire has become loosened or has pressed on the deeper surface of the skin.

As soon as the patient is out of the anaesthesia, the arm can be elevated through a full range of movements with little discomfort (Fig. 3). No other fixation except a sling is required, and the patient is quite comfortable.

In several cases when a satisfactory reduction of the fracture could not be obtained, an open reduction has been done. Through a short incision above the clavicle the ends of the fragments are placed in good position. The inner end of the outer fragment is then exposed, and a Kirschner wire is passed from this surface longitudinally through the outer fragment until it pierces the skin at the shoulder. The drill is changed to this end of the wire, and, after the ends of the fragments are again placed in good position, the wire is passed in the reverse direction, so that it crosses the fracture line into the proximal fragment. This has held the fragments in ideal position in every case. It is very easy to do; it gives adequate fixation; it is much simpler than applying plates, screws, or transverse wires through drill holes; and it allows the wire to be removed with ease if necessary.

An incision, a quarter of an inch long, over the fracture, just large enough to admit a small curved elevator, has been used to facilitate reduction in some of the difficult cases.

During the past three years twenty-nine cases have been treated by this method. In each case the fragments have united in good position (Fig. 2). There have been no complications or infections in any of the cases.

The difficulties of this operation have been discussed, and in the hands of careless operators there might be grave dangers. By rough and careless manipulation of fragments the subclavian vessels, the brachial plexus, and the apex of the pleura and lung might easily be injured. It is important also to know that the wire is traveling longitudinally through the clavicle. In careless hands it might easily pass posteriorly and injure the structures already mentioned. There is a fair margin of safety, however, because, with the shoulder drawn forward, which separates the clavicle from the region of the first rib, these important structures are fairly well away from the position where they might be injured. The subclavius muscle with the attachment of the costocoracoid membrane and other fascial planes to the deeper surface of the clavicle also provides a safety zone, separating the clavicle about half an inch from these structures.

As in the earlier days of the Smith-Petersen nail, when there were many difficulties and dangers which now have been overcome as more experience has been gained, so probably in the future the difficulties with this form of treatment will be overcome and improvements in this method of fixation of the clavicle will be devised.

It is intended to apply this principle of passing wires longitudinally through the lumen to fractures of other long bones. Those bones with a narrow medullary cavity, like the radius, the ulna, and the fibula, would seem more suitable than those with a larger cavity, such as the femur and the tibia.

## PHOTO-ELASTIC STUDIES OF BONE FORMS\*

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Recent years have witnessed wide application of the principles of photo-elastic analysis to the problems of modern engineering. When this came to the attention of the writer, a natural curiosity as to the value of the method in orthopaedic problems was aroused. Though this investigation seemed to be original, further search revealed the fact that a tentative suggestion for such a study of bone stresses had previously been made by Alexander<sup>1</sup>. An effort to discover the results of any such work has been fruitless.

Briefly, photo-elastic analysis depends upon the fact that the polymerized phenyl formaldehyde resins become birefringent under stress. During this period they acquire some of the properties of "temporary crystals", in which the molecular structure is reoriented along the lines of stress. These lines of stress are visualized under polarized light. If white light is used, the stress pattern presents a fascinating display of the colors of the spectrum, which, when photographed, appear as alternating bands of light and shadow. The use of monochromatic light does not alter the stress pattern, either qualitatively or quantitatively.

Though these birefringent resins do not even closely resemble steel, engineers have found that the stress patterns in one are closely related to those in the other substance. Resinous models of the object to be studied have been made and stressed. By an appropriate technique, these stress lines have been calibrated and a complete mathematical statement of the actual internal stresses of the original object have been determined. This has been done experimentally in engineering problems, which are so complicated that even theoretical calculation of the stresses has been found impossible. Up to the present, the method has had the serious drawback of permitting only two-dimensional studies. Recently, however, Hetenyi<sup>2</sup> discovered that the stress pattern could be "frozen" by heating and then slowly cooling the model. He has shown that the surface model presented the same stress pattern as the sectioned three-dimensional model. Not only did this permit more leisurely analysis of the surface design, but it also permitted study of the internal stresses, so as to give a three-dimensional concept of the effect of the applied force.

By analogy it seemed reasonable to inquire whether the same method might not be applied to the study of bone stresses. It was recognized at the outset that the difficulties to be encountered might be even greater than those met with in technological problems. In the first place, bone is a

\* Submitted for publication on December 23, 1939.

biological structure composed of different tissues and does not present a homogeneous crystalline material, whose physical properties can be determined as for other materials. In the second place, the physical properties of any given bone may be expected to vary from time to time under a variety of undeterminable biological conditions. In the third place, the shape of the bone must be considered to be the result of a series of forces acting in different combinations and under varying conditions of mechanical efficiency.

On the other hand, some mitigation in the complexity of the problem was found in the fact that from its biological behavior in response to stress, the internal structure of the bone could be accepted as indicating the resultant of the forces under which it had developed. It was felt that, if a sufficiently constant and similar stress pattern could be demonstrated in bone models, some conclusions might be drawn as to the relationship between bone configuration and the applied forces. Necessarily the determination of actual stress values would depend upon the development of a formula for correlating the stress pattern of the model with the internal anatomy of the bone. Because of the present lack of any such data, only rough general impressions can be noted. Yet even these seem to suggest that the method may hold some promise in the study of bone reaction to normal or abnormal stress. Particularly if pursued in a quantitative manner, photo-elastic analysis may throw some light on the normal architecture of the osseous system and may serve to explain or forecast the effect of surgical modifications of the osseous structures.

In general, it may be noted that bones are subject to two main types of forces: (1) a gravitational force, due to the superimposed body weight, and (2) a muscular force, exerted by the surrounding and attached muscles. Study of the latter force is extremely complicated, because of the facts that it is impossible to estimate the actual power of any given muscle and that at any moment each muscle may have totally different components, as a result of changing position. Preliminary observations on the effect of tension on the plastic model indicate that a distortion of the stress pattern may be accomplished by this means. But whether or not this method will suffice for the analysis of the effect of muscle pull on bone must be determined by other studies.

Up to the present, only a few observations on the effect of compressive forces have been made. They are presented not with any feeling of finality, but in the hope that they may spur others on to evaluate this principle of study. For purposes of economy, the older, two-dimensional-surface method was employed. Flat plates of catalin, three-eighths of an inch thick, were used. At a later date it is hoped to make three-dimensional-scale models, so as to avoid the possibility of a stress distortion, due to bending of the model. Though it cannot be definitely excluded, the effect of bending does not appear to have had any important part in the production of the stress patterns.

Instead of using Nicol prisms, the less expensive polaroid was

FIG. 1

Stress pattern of the upper end of the femur. Note the longitudinal arrangements of the stress lines, with interruption near the site of the epiphyseal lines of the neck and the greater trochanter.

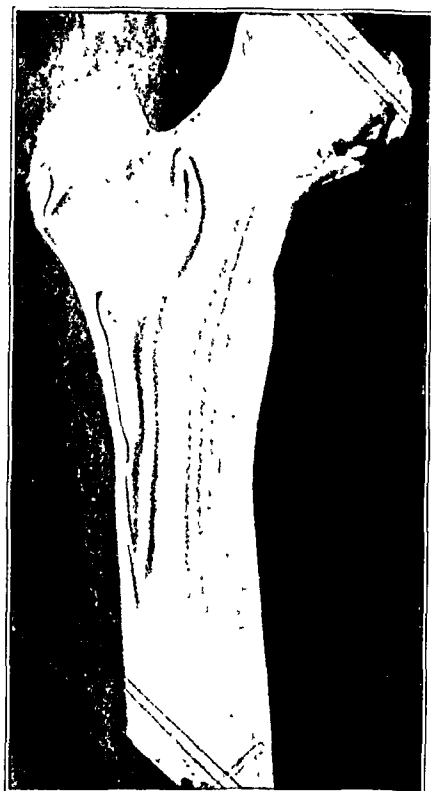


FIG. 1

mounted in frames and served the purpose of polarizing the light rays. Models of a normal femur, an osteotomized femur, an os calcis, and a whole foot were made in catalin, from roentgenographic outlines. After being annealed, these forms were subjected to tensile and to compressive forces in a simple apparatus designed by Mr. Jerome Gross.

When the outline of the normal femur was compressed, several interesting phenomena were observed (Fig. 1). In the first place, the arrangement of the lines of stress was found to be markedly reminiscent of the trabecular structure seen on longitudinal section of the femur. When the model was tilted first to one side and then the other, so as to simulate the conditions of adduction and abduction, under weight-bearing, these stress lines shifted so as to resemble first one and then the other of the longitudinal trabecular systems. The curvature of these longitudinal stress lines varied somewhat with the length of the model used, the longer models giving the better representation. In the second place, the stress lines seemed to run between the two points of compression and did not seem to radiate into the trochanteric region to any extent. The greater number of stress lines appeared to be on the medial side of the shaft, toward the line of the mechanical axis of the normal femur.

FIG. 2

The stress pattern of a femoral model under compression and under tension at the sites of muscular attachments.



FIG. 2





FIG. 3

The stress pattern of the os calcis, when the outline of the standing foot was compressed at the upper surface of the astragalus.

The resulting distortion in the stress pattern is clearly seen (Fig. 2).

To determine whether these were purely fortuitous occurrences, other bone forms were examined. A model of the heel bone was prepared and stressed in the usual manner, except that, instead of a two-point, a three-point application of the force to simulate normal weight-bearing was employed. Here, as in the case of the upper end of the femur, a noteworthy resemblance of the stress lines to the normal trabecular structure of the os calcis was found (Fig. 3). In addition to the interesting

In the third place, the stress lines seemed to stop in an area which was situated close to the normal epiphyseal zone. This stress pattern was repeatedly reproduced. It could be modified by adding the element of traction to that of compression. By means of holes drilled through the model, tension wires, to represent the trochanteric muscles, were attached and made taut by traction screws. The re-



FIG. 4

Model of a Lorenz bifurcation, with weight on the apex of the distal portion.



FIG. 5

Model of a Lorenz bifurcation, with weight on the femoral head.

stress lines, a specially heavy shadow was found at the back of the os calcis, situated in the region and in the direction of the normal epiphyseal line.

The close resemblance between the observed lines of stress and the known trabecular arrangement of normal bone naturally suggested the possibility of studying changes in bone form. It is common knowledge that, in growing bone, accidental changes in the axial alignment cannot be expected to persist as in adult bone. In some instances, such as the spontaneous correction of bow legs or the rectification of malaligned fractures, this tendency is benevolent. In other changes, such as occur after any of the various osteotomies, this tendency may be extremely disturbing. In a general way this has been recognized as a growth response to altered stresses, but no more detailed explanation has been offered.

However, photo-elastic studies seem to offer objective data on this question. A model of a Lorenz bifurcation was made and stressed, first at the upper end of the distal fragment and then directly over the femoral head. In the former instance the stress lines were located mainly along the medial aspect of the femoral shaft (Fig. 4). In the latter instance the stress lines shifted mainly toward the outer aspect of the bone, in the direction in which the mechanical axis of the femur had been displaced (Fig. 5). An almost identical situation was noted when a model outlined from a roentgenogram showing a Schanz osteotomy was stressed under identical circumstances (Fig. 6). Though the general longitudinal arrangement consistent with a two-point application of force persisted, the majority of the stress lines were located along the lateral border of the femur. The area at the base of the trochanter showed typical stress lines, while the region of the lesser trochanter showed few, if any, signs of stress orientations.

This seemed to indicate the importance of the concept of the mechanical as compared with the anatomical axis of the bone. It tended to explain the deposition of bone on its concave side. In those cases in which the mechanical axis lies outside of the anatomical axis, there is a shifting of the stress to the outer side. In consequence, bone is laid



FIG. 6

Stress pattern of an osteotomized femur (Schanz type).

down along this surface and the femur tends to be converted back to a straight line. When the mechanical axis lies medially, the same process takes place, and may be recognized by the thickness of the inferior border of the femoral neck along Adam's bow. Indeed, it is only the concomitant increase in length of the femoral neck which prevents the conversion of the femur into a straight rod. In other words, if it can be assumed that the lines of stress seen in the model do or can be made to represent the actual loading conditions of a bone, the photo-elastic appearance of those lines present experimental confirmation of both Roux's and Wolff's laws of bone growth and transformation.

It is hardly necessary or at all possible to indicate the variety of clinical and theoretical problems which may be submitted to analysis by this method. The experience of the engineering profession indicates quite clearly that by means of calibrated instruments and a technical knowledge far beyond the writer's capacities, a complete and accurate quantitative estimation of internal stress can be obtained.

However, even the qualitative observations here reported may be of value in indicating the power of the method in the approach to bio-mechanical problems. They seem to present an experimental means of studying the relationship between the form and the function of osseous structures. They indicate that, from a study of the stress pattern, some light may be cast upon the significance of various forces in determining the configuration of the bone. They show how and why the surgical modification of the form of a bone, and particularly of growing bone, undergoes a secondary change in response to the new stresses. They suggest that with fuller knowledge the ultimate form of the osteotomy may be made to occur along predetermined lines of stress.

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# "DORSAL BUNION": ITS MECHANICS AND OPERATIVE CORRECTION \*

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"Dorsal bunion" is the term suggested for a pathological condition of the big toe, consisting of a plantar-flexion contracture at the metatarsophalangeal joint with a more or less pronounced dorsiflexion contracture of the first metatarsal at the cuneiform joint.

The "bunion" in the majority of cases is caused by dorsal protrusion of the head of the first metatarsal as a result of the dorsiflexed position of this bone. The writer wishes to give especial emphasis to the latter component of this deformity, as the faulty position of the first metatarsal is frequently overlooked in spite of the fact that it plays an important part in the deformity and in its correction. That is why simple removal of the dorsal exostosis, or resection of the basal phalanx (Davies-Colley, Keller, Brandes) recommended by Hohmann, or any other operative procedure without correction of the faulty position of the first metatarsal usually results in a prompt recurrence of the deformity.

With the exception of Hohmann's classic book, "*Fuss und Bein*", the author has been unable to find any satisfactory description of this deformity in the literature. In the second edition of his book, Hohmann discusses what he calls "*Hammerzehen-Plattfuss*" (hammer-toe-flat-foot). His suggestions as far as the treatment is concerned are rather vague.

The hammer-toe deformity of the big toe, or hallux malleus, consisting of a dorsiflexion contracture at the metatarsophalangeal joint with a plantar-flexion contracture at the interphalangeal joint, is exactly the opposite

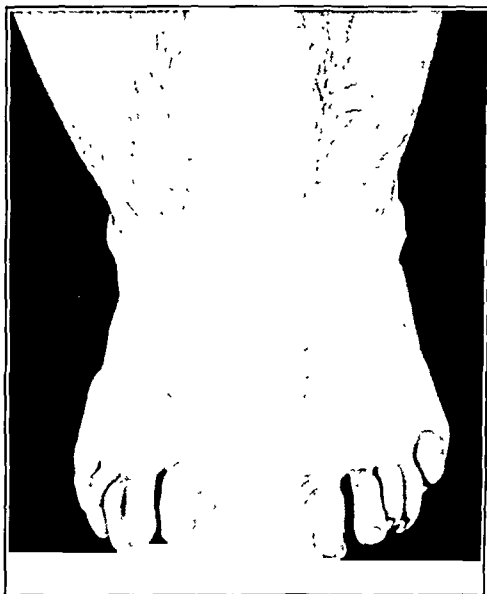


FIG. 1

Feet of a man, twenty-one years old, with multiple hammer toes and hallux malleus. Note the heavy callosity over the knuckle of each big toe.

\* Received for publication on October 24, 1939.

† Service of Leo Mayer, M.D.

deformity of dorsal bunion and should not be confused with it (Fig. 1).

### ETIOLOGY

Dorsal bunions may be divided etiologically into four groups according to the type of associated deformity:

1. In cases of hallux rigidus;
2. In paralytic deformities of the foot (flaccid and spastic);
3. In congenital club-foot;
4. In severe congenital talipes planovalgus.

### *In Hallux Rigidus*

Usually there is restriction or even complete loss of dorsiflexion of the basal phalanx, due to shrinking of the plantar part of the joint capsule and also because of incongruity of the articular surfaces. Often there is pronounced production of bone on the dorsum of the head of the first metatarsal, causing bone block.

In the more advanced cases (Fig. 2) actual dorsiflexion of the first metatarsal takes place in the following manner:

Dorsiflexion of the big toe is painful, and, therefore, the patient subconsciously keeps the big toe in plantar flexion at the metatarsophalangeal joint. He also holds the forefoot in slight supination, in order to avoid weight-bearing on the ball of the big toe. In time a fixed plantar-flexion contracture of the big toe develops. The normal medial weight-bearing point beneath the sesamoids of the first metatarsal is now shifted forward to the plantar aspect of the interphalangeal joint. A heavy callosity is often noted beneath the latter joint, while the skin

of the ball of the big toe becomes unusually soft. The proximal phalanx of the big toe loses its normal horizontal position; its head is pushed against the ground, while its base is elevated. The impact of the ground against the plantar-flexed basal phalanx is transmitted to the head of the first metatarsal, tending to displace this head dorsally. Moreover, the continuous contraction of the supinators

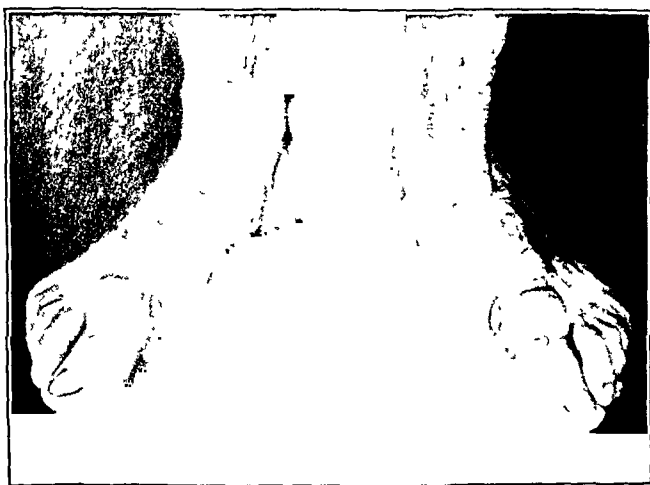


FIG. 2

Dorsal bunions in a case of bilateral hallux rigidus in a man, twenty-seven years old. Considerable plantar-flexion contracture at the first metatarsophalangeal joint is present. Note also dorsiflexed attitude of the first metatarsal, so that the ball of the big toe does not touch the ground.

of the foot (mainly the tibialis anterior) contributes further toward dorsal displacement of the first metatarsal.

*In Paralytic Deformities of the Foot (Flaccid and Spastic)*

The paralytic dorsal bunion may be caused by at least three different combinations of paralyzed muscles:

1. *Weakness of the peronei with a strong tibialis anterior and strong flexors of the big toe:* Because of the varus position in these cases, the forefoot is deprived of its medial weight-bearing point beneath the sesamoids of the big toe. Furthermore, a strong tibialis anterior brings the first metatarsal into dorsiflexion, particularly since it is not opposed by the action of the peroneus longus, which is a plantar flexor of the first metatarsal. In an attempt to create a new medial weight-bearing point, the patient bends the big toe downward, using its strong flexors. Thus favorable conditions for dorsal-bunion formation are created.

The author has observed several cases where a dorsal bunion was formed following transplantation of the peroneus longus by the intra-sheath method (Mayer) into the tendon of the paralyzed tibialis anterior (Figs. 3-A and 3-B). The transplanted tendon of the peroneus longus became overactive, causing supination of the forefoot and dorsiflexion of the first metatarsal, with development of a dorsal bunion.

Dorsal-bunion formation in cases of spastic paralysis with overactive supinators of the foot and flexors of the big toe, as shown in Figure 4-A, needs no further comment.



FIG. 3-A



FIG. 3-B

Calcaneus deformity following anterior poliomyelitis in a boy, sixteen years old. Transplantation of the peroneus longus into the tibialis anterior had been performed elsewhere several years before this photograph was taken. A dorsal bunion formed as a result of overactivity of the transplanted peroneus longus, which at operation was found to be considerably hypertrophied.

2. *Weak dorsiflexors of the foot and toes with strong plantar flexors of the big toe and strong calf muscles:* In these cases the plantar flexors of the big toe prevail, being unopposed by the dorsiflexors. The big toe gradually forms a plantar-flexion contracture at the metatarsophalangeal joint. The base of the proximal phalanx subluxates plantarward under the head of the first metatarsal and pushes the latter dorsally, causing dorsiflexion of the first metatarsal, and a dorsal bunion is formed.

In this group of cases, the same deformity as in the first group is produced, but in a reversed sequence of mechanical forces. In the first group, with strong dorsiflexors, the dorsiflexion of the first metatarsal develops first, followed by a plantar-flexion contracture of the big toe. In the second group, with weak dorsiflexors and strong plantar flexors, the plantar-flexion contracture of the big toe is apparently the primary deformity with the dorsiflexion of the first metatarsal developing as a secondary condition.

3. *Calcaneus deformity with active plantar flexors of the big toe:* The patient belonging to this group uses the flexor hallucis longus as an accessory plantar flexor of the foot. At the same time, a plantar-flexion contracture of the big toe is produced, and this may lead to dorsal-bunion formation, as already outlined.



FIG. 4-A

Left dorsal bunion in a boy, twelve years old, with spastic paralysis. The left gastrocnemius, tibialis anterior, and flexors of the big toe were overactive. Note the prominence of the tendon of the left tibialis anterior. Considerable dorsiflexion of the first metatarsal was present. (Private case of Dr. M. S. Burman, who performed the operation with the author's assistance. The author is indebted to Dr. Burman for his permission to use this case.)

Variable combinations of these three major types of muscle weakness leading to dorsal-bunion formation may be observed.

### *In Congenital Club-Foot*

Mechanical factors responsible for dorsal-bunion formation occasionally seen in congenital club-foot where the supination of the forefoot has not been adequately corrected are similar to those already described in cases of paralytic talipes varus. (Fig. 5)

### *In Severe Congenital Talipes Planovalgus*

This is rather a rare deformity, probably of congenital nature. The main features observed in this type of foot are a short Achilles tendon and plantar flexion of the os calcis and the talus, the long axis of the latter often approaching a vertical line. The forefoot, on the contrary, is held dorsiflexed in the mid-tarsal joints. All of these create a so-called "rocker-bottom" deformity of the sole. On the whole, this type of foot bears a close resemblance to the foot of the ape.\*

Furthermore, Böhm has shown that the foot of a human embryo

\* This resemblance is so striking that Prof. F. Weidenreich, the well-known anatomist and paleontologist, and author of numerous works on comparative anatomy and evolution of the foot, at a first glance mistook the lateral roentgenogram of the feet shown in Figure 7-B for those of a gorilla.

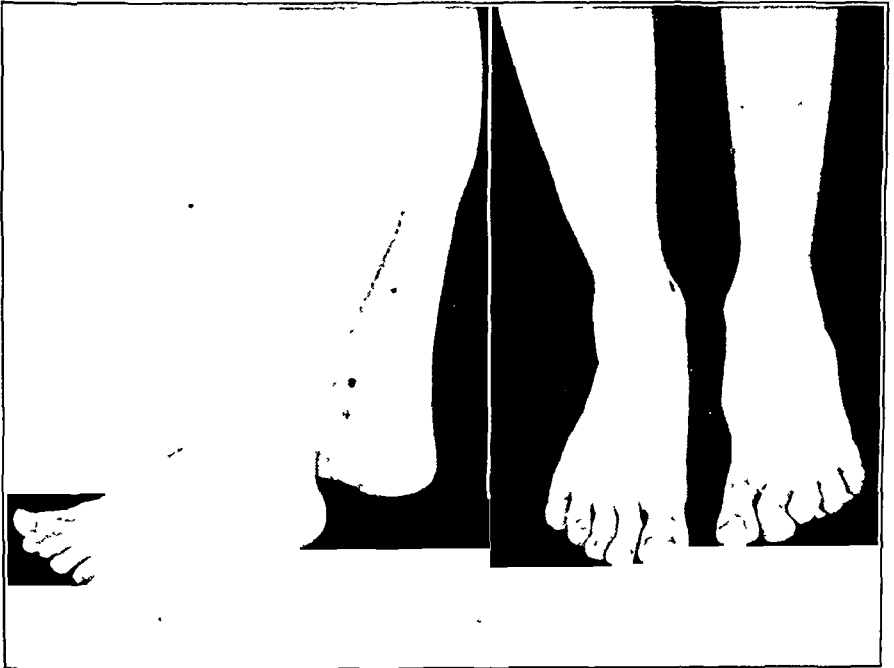


FIG. 4-B

Same case after operation performed on April 19, 1932. The head of the first metatarsal now rests on the ground. Flexion of the big toe and the dorsal bunion have been entirely corrected.





FIG. 5

Dorsal bunion in inadequately corrected congenital club-foot. Note dorsiflexion of the first metatarsal and also of the first cuneiform. Fusion of the calcaneocuboid joint is the result of a previous reconstruction operation.

at the beginning of the third month also possesses many of the features noted in congenital flat-foot and in the foot of the ape.

The author, therefore, believes that the occurrence of congenital flat-foot may be explained on the basis of arrest of its embryonal development in the early ape-like stage.

Most probably the dorsal bunion in these cases is a secondary condition, developing after the child begins to walk. The author ventures to offer the following explanation for dorsal-bunion formation in this group.

The short Achilles tendon calls for the compensatory overactivity of the dorsiflexors of the foot, mainly the tibialis anterior. Contraction of the latter muscle gradually leads to dorsiflexion of the first metatarsal. Thus, conditions are created which favor formation of the dorsal bunion in a manner already outlined.

The writer has had the opportunity of operating upon only one patient belonging to this group (Figs. 7-A through 7-D).

#### DESCRIPTION OF THE OPERATION

In cases of severe dorsal bunion the following operation is offered.

The operation is performed under a tourniquet applied at the middle of the calf. A longitudinal incision is made over the dorsomedial aspect of the big-toe joint. The dorsal capsule of the first metatarsophalangeal joint is exposed, and a dorsal tongue-shaped flap, with its base attached

Composite, somewhat schematized drawing of the operative technique (actually made from the roentgenograms of Case D. S.). *Not all the steps of the operation illustrated have been used in each of our cases.* Shaded area over the bones represents the wedge resection.

*C*: Capsule of the first metatarsophalangeal joint, shown by heavy black line.

*A.T.*: Tendon of tibialis anterior; *A'T'*: its stump, after transplantation.

*P.T.*: Tendon of tibialis posterior.

*F.H.L.*: Flexor hallucis longus. In Fig. 6-B it is shown translocated on the dorsum of the foot through an oblique channel in the shaft of the first metatarsal.

*F'H'L'*: Distal stump of flexor hallucis longus.

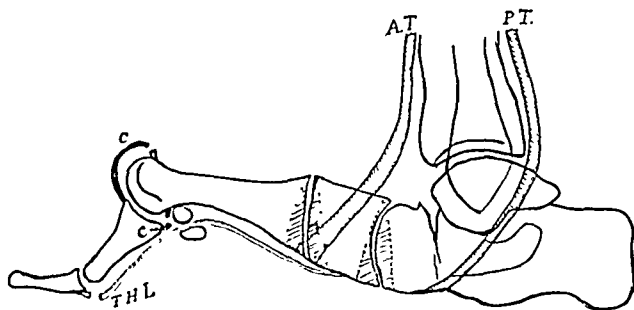


FIG. 6-A

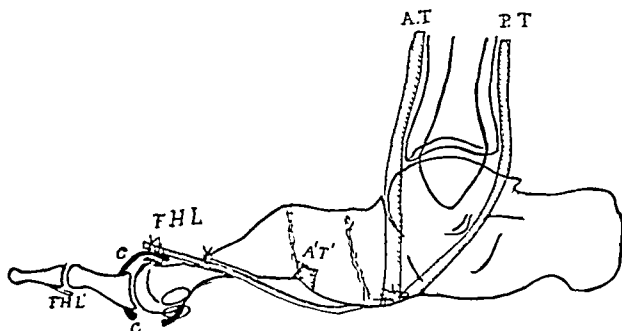


FIG. 6-B

to the basal phalanx, is outlined (Figs. 6-A and 6-B). The joint cavity is opened by reflecting this capsular flap distally. Usually a slight dorsal projection over the head of the first metatarsal requires shaving off.

Another incision is made along the dorsomedial border of the forefoot. The first cuneiform-metatarsal joint and, if necessary, the first cuneiform-navicular joint are exposed. In some cases (as in congenital talipes planovalgus) with an overactive tibialis anterior, the latter is detached from its insertion and translocated backward into the tendon of the tibialis posterior. Thus its dorsiflexion action upon the first metatarsal ray is eliminated. Also the leverage of the tendon of the tibialis anterior is diminished, due to backward shifting of its insertion nearer to the axis of motion in the tibiotalar joint. A wedge-shaped resection with a plantar base is then performed at the first cuneiform-metatarsal joint and, if necessary, also at the first cuneiform-navicular joint. The width of the base should be calculated with precision in each case in order to secure close approximation of the resected bone surfaces.

In some of the author's cases of dorsal bunion, following anterior poliomyelitis, dorsiflexion of the first metatarsal was associated with more or less marked metatarsus varus primus and hallux valgus. This additional deformity can be simultaneously corrected according to the technique described by the author in 1934.

The flexor hallucis longus tendon is then severed from its insertion and is pulled out proximally into the wound over the forefoot. An oblique channel, running from the proximal plantar aspect to the distal dorsal aspect, is drilled in the shaft of the first metatarsal. The end of the flexor

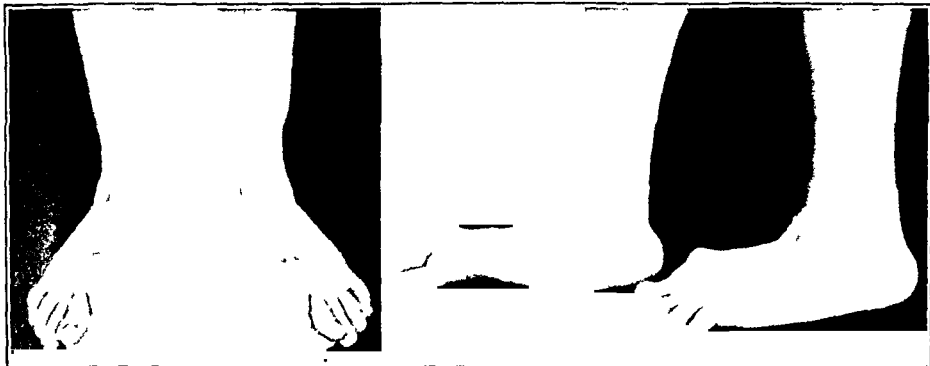


Fig. 7-A

D. S., male, nineteen years old. Anterior and lateral views of severe planovalgus deformity, probably of congenital type. Note rocker-bottom deformity of soles, with marked dorsal bunions.

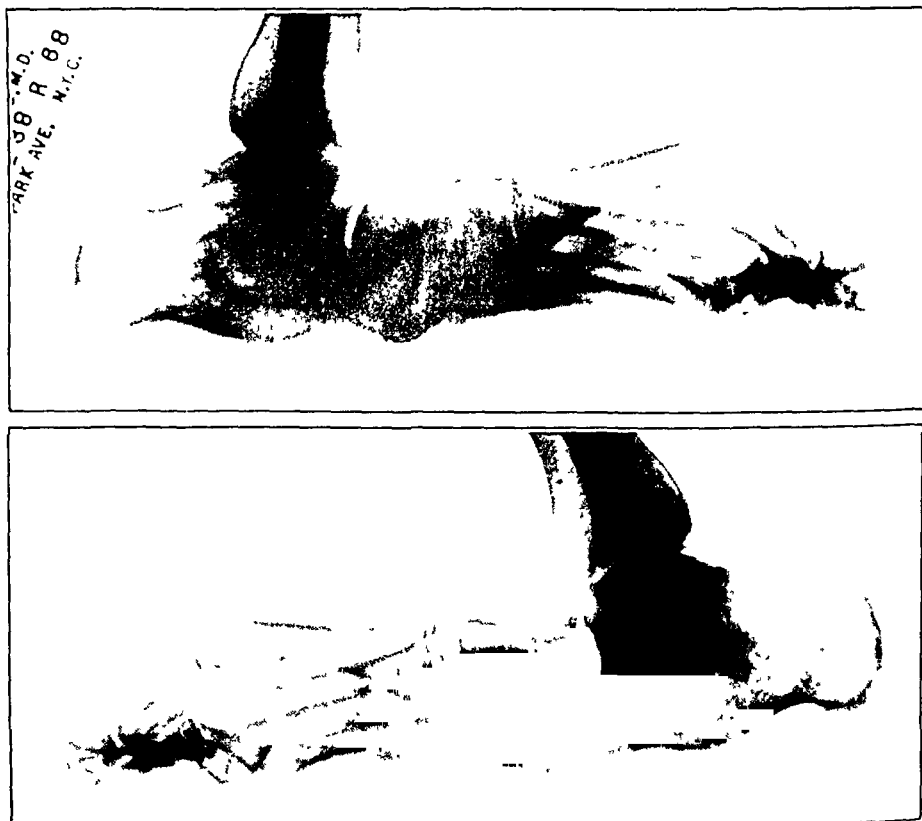


FIG. 7-B

D. S. Lateral roentgenograms before operation. There is marked dorsiflexion of the first metatarsal with dorsal displacement of the first cuneiform. The head and part of the neck of the talus are absent, and there are considerable productive osteo-arthritic changes in the talonavicular joint. The talocalcaneal joint appears to be ankylosed. The tibia is drawn forward toward the forefoot apparently by the overactive tibialis anterior. The os calcis is in slight plantar flexion. Note the rocker-bottom deformity caused by plantar convexity of the mid-tarsal joints.

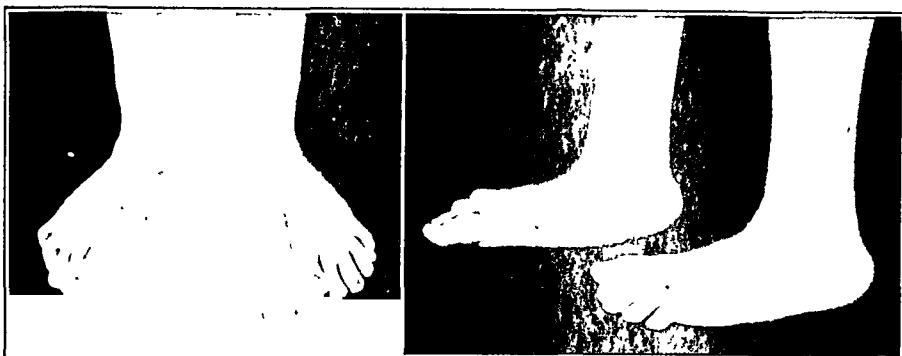


FIG. 7-C

D. S. About a year after the operation, performed on July 6, 1938, showing satisfactory correction of the deformity. The ball of the big toe now rests on the ground.

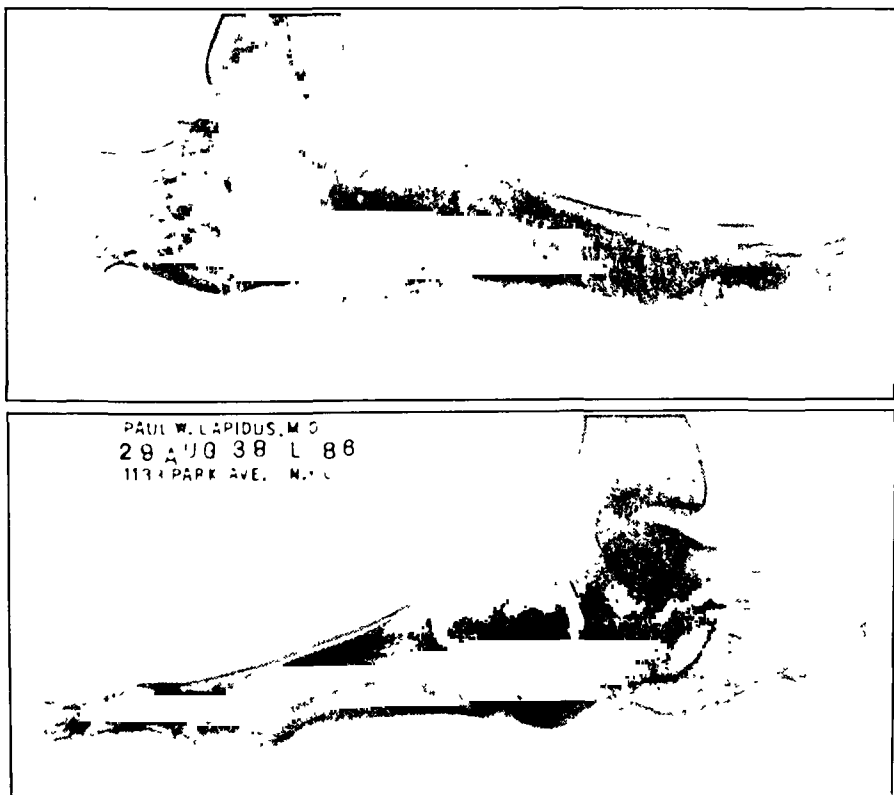


FIG. 7-D

D. S. Roentgenograms after correction. The faulty position of the whole first ray is entirely corrected. Note that forward bending of the tibia is eliminated because of transplantation of the tendon of the tibialis anterior into the tibialis posterior. Thus the tension of the tibialis anterior has been released and the leverage diminished, as its insertion is now shifted backward nearer to the axis of motion in the tibiotalar joint. (See Figs. 7-A and 7-B.)

hallucis longus tendon is threaded with a special tendon stitch and pulled dorsally through the bone channel into the wound over the toe.

The author feels that this transplantation of the flexor hallucis longus tendon into the shaft of the first metatarsal should be considered in addition to wedge osteotomies, especially in paralytic cases with strong flexors and weak extensors of the big toe. This converts the flexor hallucis longus into a plantar flexor of the first metatarsal, and simultaneously its plantar-flexion action upon the big toe is eliminated.

Subcutaneous plantar tenotomy and capsulotomy are then performed over the metatarsophalangeal joint just distal to the sesamoids,\* and the plantar-flexion contracture of the big toe is thoroughly corrected.

The dorsal tongue-shaped flap is then resutured with enough reduplication (as in a double-breasted coat) to keep the big toe in a few degrees of dorsiflexion. The hallux valgus, if present, is also corrected by resuturing the flap with somewhat more tension on its medial (tibial) side. The distal end of the transplanted flexor hallucis longus tendon is then anchored into the tongue-shaped flap and acts as passive reinforcement of the dorsal capsule. One or two stitches are taken through the tendon and the periosteum at the dorsal opening of the bone channel in order to prevent the displacement of the tendon before it becomes adherent to the bone. A loose plaster casing is applied.

In about two weeks another unpadded walking plaster casing is applied, allowing dorsiflexion of the big toe, and the patient is gradually permitted to walk with crutches. This plaster casing is kept on for about two months. After that the patient is given well-fitted steel foot plates, and physical therapy is instituted.

Since April 19, 1932, a total of six † patients have been operated upon by this method, with encouraging results. Four cases followed anterior poliomyelitis; one was the result of spastic paralysis (Figs. 4-A and 4-B); and one belonged to the talipes planovalgus group (Figs. 7-A through 7-D).

#### COMMENT

In conclusion, the author wishes to state that the dorsal-bunion symptom-complex may be a result of a number of variable ailments and deformities of the foot.

The operative approach described is offered only as an outline for those who may attempt to operate upon these cases. The author wishes to emphasize the fact that each foot may present its own problems, and, consequently, the operation should be modified to fit each individual case.

The author wishes to express his thanks to Dr. Leo Mayer for his friendly criticism of the manuscript.

\* In all our cases the capsulotomy was performed distal to the sesamoids without any untoward results. The author, however, sees no objection to performing the capsulotomy proximal to the sesamoids, thereby preventing their possible posterior displacement, the functional importance of which has been emphasized by Dr. D. J. Morton.

† A seventh patient (post-poliomyelitis) has been operated upon only recently by Dr. Leo Mayer, but this case is not included in this report.

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# ATROPHIC CHARCOT'S HIPs

## REPORT OF FIVE CASES

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Charcot's joints are not an uncommon finding in *tabes dorsalis*. The more common type, the hypertrophic joint reaction, has been described in detail in many early reports, while the less common variety, the atrophic group, has had little mention to date.

Various theories as to the pathogenesis of this condition have been offered. Thomas and Kudelski believe that a basic sympathetic condition is the cause of the disintegration of the joint. Oberthur, Delbet and Cartier, and Marinesco, Sager, and Kreindler are of the same opinion. Wile and Butler state that in every case involvement of the joints is associated with destruction of their afferent and proprioceptive nerves, rendering the joints unable to compensate for injury. Histological studies have been made by Moritz and Bologna, while the associated physiology has been described by Marinesco and Sager. Hamill reports a case in which trauma was the contributing cause of the condition.

We are herein describing five cases of atrophic Charcot's hips, seen in the Cook County Hospital during a two-year period. In only one of these cases was the condition bilateral. There were three females and two males, and their ages ranged from forty to fifty-nine years. The duration of the joint conditions preceding the diagnosis varied from one to six years. Diagnosis was made by clinical examination; each of the patients had a triad of positive symptoms with a positive blood or spinal-fluid Wassermann reaction. The blood Wassermann reaction was positive in four instances and negative in one. The spinal-fluid Wassermann reaction was positive in two cases and negative in three.

All of the joints were painless with an undue amount of mobility, as in Case 1 (Figs. 1-A and 1-B). Roentgenograms revealed a characteristic loss of bone substance and diminished reaction rather than the proliferative, irregular deposit of the hypertrophic type. In one instance—Case 1 (Figs. 1-A and 1-B)—the head remained in the acetabulum, the entire neck being absorbed; in the remaining cases (Figs. 2, 3, 4, and 5) there was an entire absorption of the neck and head of the femur, the trochanter remaining clear of the acetabulum and completely out of the joint. There seemed to be a slight thickening of the joint capsule, which receives the strain of the weight, in two cases,—Case 3 (Fig. 3) and Case 4 (Fig. 4). Shortening and instability were prominent in all cases. Among our cases of Charcot's hips we have encountered several of the hypertrophic variety, and we are including a roentgenogram (Fig. 6) of one of these cases for comparison. A differential diagnosis from septic or tuberculous hip may easily be made.

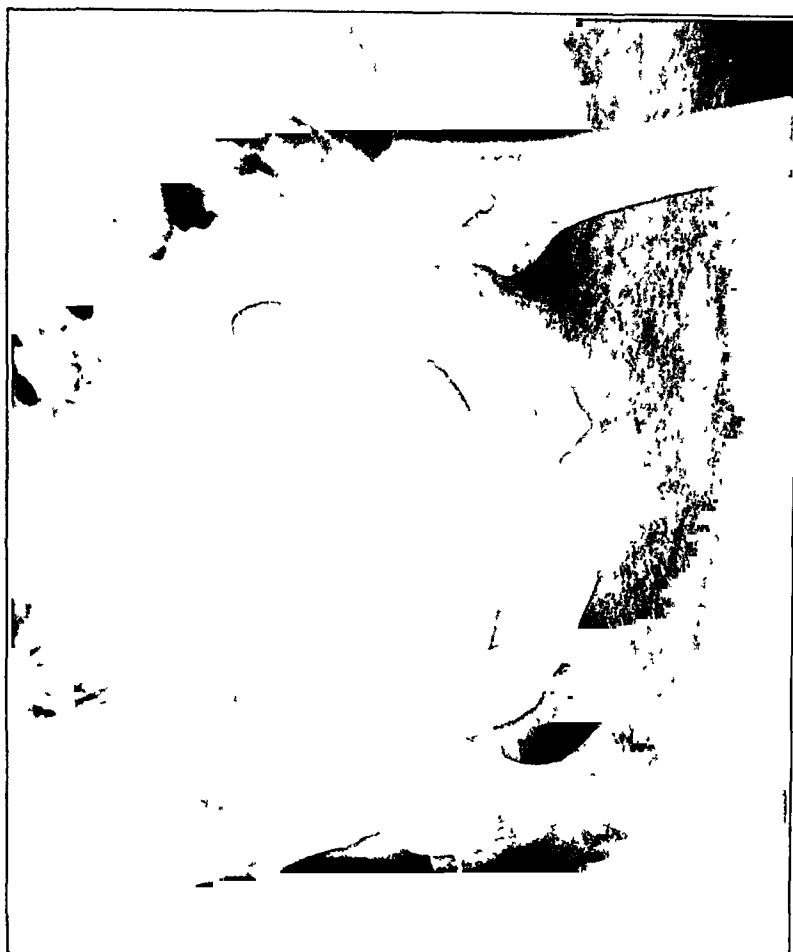


FIG. 1-B

Case 1. Postoperative roentgenogram. The head has been removed, and the trochanter has been nailed.

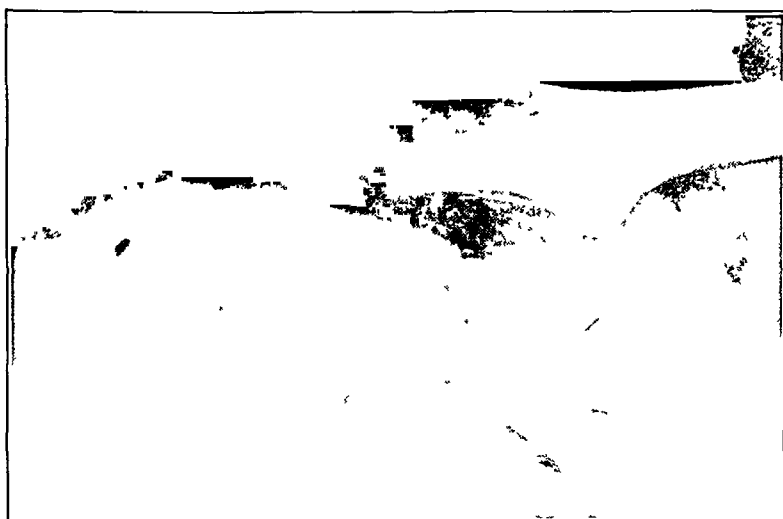


FIG. 1-A

Case 1. W. R. Roentgenogram of the left hip, showing marked absorption of the neck of the femur with the trochanter riding high against the iliac crest. The head of the femur is markedly atrophic.



The disability in all instances was so severe that modified bed rest was essential, with short periods of ambulation. At the primary examination of the patient in our first case, an old fracture of the neck of the femur was considered. This was excluded in view of the positive Wassermann reaction and the absence of pain in the joint. A diagnosis of Charcot's disease having been made, a Whitman reconstruction of the head was done with an excellent result. The patient, however, died of aggravated tabes dorsalis symptoms, cystitis, and pyelitis. Braces were applied in the other four cases. Since the necessary constant care and reeducation in walking could not be given in a charitable institution, three patients were transferred to a convalescent home, where antiluetic treatment was given.

Table I shows the sex and age of the patients, the duration of symptoms, the treatment, and the results in the cases reported.

#### CASE REPORTS

CASE 1. W. R., male, aged fifty-two years, a clerk, stated that in September 1934 he had noticed a "click" of the left hip while he was moving from one seat to another in a street car, which made a sudden stop. Since then he had complained of weakness, shortening of this extremity, and a limp.

Roentgenographic examination (Fig. 1-A) at the Clinic of the Cook County Hospital on March 30, 1935, revealed marked absorption of the neck with part of the head remaining. Physical examination revealed Argyll Robertson pupils with loss of deep reflexes.



FIG. 2

Case 2. M. C. Roentgenogram showing marked absorption of head and neck of right femur. There is no bone reaction; the trochanter is riding high against the iliac area.

Because the head was inadequate for a Brackett operation, a Whitman reconstruction operation was done, with an excellent result (Fig 1-B). Seven days after the operation a septic temperature and delirium developed, and the patient went into a coma and died. The post-mortem examination revealed infected diverticula of the bladder, with an ascending pyelitis, generalized peritonitis, bronchopneumonia, and luetic aortitis.

CASE 2. M. C., female, aged fifty-one years, a housewife, in June 1936 had first noticed a lump and swelling of the right hip. A "heavy feeling" of the legs became constant and severe, and in October 1937 she sought help at the Clinic, where she gave a history of treatment for her "blood" at various times.

Neurological examination revealed the ab-



FIG 3

Case 3. B. K. Roentgenogram showing marked atrophy of neck and head of left femur.



FIG 4

Case 4. M. C. Roentgenogram showing marked atrophy of the head and neck of both femora. There is some evidence of a sclerosis of the trochanter and the adjoining iliac area. This is the only bilateral case.



FIG. 6

Roentgenogram of hypertrophic type of Charcot's hip. Notice the extensive amount of bone overgrowth and the disintegration of the joint as compared with the atrophic variety.



FIG. 5

Case 5. G. A. Roentgenogram showing marked atrophy of the head and neck of the right femur with upward displacement of the trochanter.

sence of knee jerks, a normal position sense, and a loss of the deep reflexes. The pupils reacted poorly to light and accommodation. The blood Wassermann reaction was 3 plus; the spinal-fluid Wassermann reaction was negative.

The patient refused surgery, and a hip caliper was ordered for support. At present she is in a sanatorium, her condition being unchanged.

CASE 3. B. K., female, aged forty years, a housewife, was admitted to the Cook County Hospital on May 2, 1937, with a fracture of the left femur. The leg was put up in Buck's extension for two months. At the end of this period, there was marked shortening of the extremity, but no pain. (See Figure 3.)

Neurological examination revealed a positive Abadie sign and a loss of deep sensation. Argyll Robertson pupils were present. The blood Wassermann reaction was 3 plus; the spinal-fluid Wassermann reaction was 2 plus.

The patient refused surgery, and a brace was used. She continues to get around with crutches.

CASE 4. M. C., male, aged fifty-nine years, unemployed, noticed a general shortening of his body and a marked waddling gait, without pain. He entered the Clinic for treatment in April 1935.

The blood Wassermann reaction was 3 plus, and the Kahn test was 4 plus. Physical examination revealed a short, peculiar, telescope-like appearance of the spine, the absence of deep reflexes, loss of sensation, and the presence of Argyll Robertson pupils.

The patient is receiving antiluetic therapy and gets around fairly well with the aid of crutches. This was the only bilateral case.

CASE 5. G. A., female, aged fifty-one years, a housewife, entered the Clinic on January 2, 1935. She stated that in 1930 she had complained of severe "girdle pains" and "shooting pains" down the legs. Cordotomy was done in 1931, with relief of pain. The patient had then noticed a limp and swelling of the right hip and had experienced difficulty in walking. The spinal-fluid Wassermann reaction was 1 plus, and the Kahn test

TABLE I  
SUMMARY OF CASES

Case No.	Name	Sex	Age (Years)	Duration of Symptoms (Years)	Tests for Syphilis		Treatment	Result
					Blood	Spinal Fluid		
1	W. R.	Male	52	1	+++	—	Whitman reconstruction operation	Death, due to complications
2	M. C.	Female	51	2	+++	—	Hip caliper	Sent to sanatorium
3	B. K.	Female	40	1	+++	++	Buck's extension Hip caliper	Sent to sanatorium
4	M. C.	Male	59	2½	+++	—	Antiluetic therapy	Patient ambulatory
5	G. A.	Female	51	6	—	+	Hip caliper	Sent to sanatorium

was negative. In 1934 a trophic ulcer of the left foot developed, and antiluetic treatment with heavy metal was instituted.

The patient refused surgery and was sent to a sanatorium with a hip caliper for support.

### CONCLUSIONS

The incidence of the atrophic variety of Charcot's hips is not as uncommon as one would suppose. The five cases reported occurred within a relatively short period of time. The diagnosis must be thought of when there is a triad of symptoms associated with an increased mobility of the joint and a positive blood or spinal-fluid Wassermann reaction. The treatment to date has been very unsatisfactory, although the administration of heavy metals should be tried. Surgery was not of any assistance in our single case and is not advised except in certain isolated cases, particularly when diagnosed very early. The prognosis for recovery, as well as for function of the joint, is poor.

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# OSTEOID-OSTEOMA: FURTHER EXPERIENCE WITH THIS BENIGN TUMOR OF BONE

WITH SPECIAL REFERENCE TO CASES SHOWING THE LESION IN RELATION TO SHAFT CORTICES AND COMMONLY MISCLASSIFIED AS INSTANCES OF SCLEROSING NON-SUPPURATIVE OSTEOMYELITIS OR CORTICAL-BONE ABSCESS \*

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In 1935, one of us (H. L. J.)<sup>5</sup> called attention, under the heading of *osteoid-osteoma*, to a benign neoplastic lesion of bone which had apparently not hitherto been described. The article in question gave clinical, roentgenographic, and pathological details in regard to the five instances on the basis of which the condition originally became crystallized in the mind of the author. In a footnote, added when proof of that article was corrected, he was able to state that he had already observed three additional cases of the condition. Not long after this, when he demonstrated the lesion at a meeting of pathologists, there were already eleven instances to report.<sup>6</sup> Since then, twenty-two additional cases have accumulated, so that our total experience with the lesion now covers thirty-three cases.

In the original article it was stated that, in the cases seen, the lesion began its development in spongy bone. Subsequent experience has shown that it can also start, if not within the substance of bone cortex, at least on its periosteal or medullary surface. In fact, our present thirty-three cases of osteoid-osteoma include thirteen instances in which the lesion developed in the shaft cortex of a long bone. These cases, like those in which the lesion was in spongy-bone areas, were misinterpreted clinically as instances of chronic osteomyelitis or of bone abscess. More particularly, the cases in which the lesion was in the shaft cortex had been misclassified clinically as representing so-called "sclerosing non-suppurative osteomyelitis" or else "intracortical-bone abscess". It is mainly because of the wider conception of osteoid-osteoma opened up by these shaft-cortex cases that this second article is being presented.

## CLINICAL ASPECTS

### *Sex and Age Incidence*

Of the thirty-three patients, twenty-two were males and eleven were females. There may be significance in this preponderance of males, but the number of our cases is really too small to permit statistical generalization.

As to the age incidence, it is clear that the disorder has a predilection

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for adolescents and young adults. We have age records on thirty of the thirty-three patients. It is striking that all but five of these thirty were between eleven and twenty-four years of age. Tabulation, by five-year periods, of the ages of the patients at the time of admission to the hospital shows the following distribution:

<i>Age</i>	<i>No. of Cases</i>	<i>Age</i>	<i>No. of Cases</i>
1 to 5	1	21 to 25	.. . 9
6 to 10	0	26 to 30	. . . 3
11 to 15	. 5	31 to 35	. . . 1
16 to 20	11	Total	. . . 30

The youngest patient was four years of age and the oldest, thirty-three.

#### *Distribution and Location of the Lesions*

The following table lists the various bones affected and, in descending order of frequency, the number of times each was found to be involved in the thirty-three cases.

<i>Bone Involved</i>	<i>No. of Cases</i>	<i>Bone Involved</i>	<i>No. of Cases</i>
Tibia	8	Patella	1
Femur	7	Calcaneum	1
Phalanges (pedal)	3	Tarsal navicular	1
Vertebrae	3	Astragalus	1
Ulna	2	Ankle region (site not precisely given)	1
Phalanges (manual)	2		—
Fibula	2		
Humerus	1	Total . . . .	33

So far, then, we have found the lesion in bones of the limbs and of the vertebral column (exclusive of the sacrum), but not yet in ribs, innominate bones, or skull bones. As to the limbs, the bones of the lower ones are much more commonly affected than those of the upper. In regard to the skull, it should be noted that a lesion appearing in the bones of the nasal sinuses has been described which bears at least some resemblance to osteoid-osteoma and which will be considered later in our discussion of the literature (p. 680).

When the lesion arises in the spongiosa, it usually, though not necessarily, incites a perifocal osteosclerosis of greater or lesser extent. The lesion may be well buried in spongiosa. It is particularly likely to be so when it develops in the spongy end of a long bone. However, we have seen one instance in which the lesion developed immediately beneath an articular cartilage. A rather superficial location is fairly common when the lesion develops in small bones consisting mainly of spongiosa. Under these circumstances, it often abuts upon, and even erodes, the overlying cortical shell. It may then elevate the periosteum, but it does not penetrate the latter and may not even stimulate it to the excessive formation of new bone.

Arising in the cortex of a long bone shaft, the lesion usually provokes a more extensive reaction. If it develops toward the outer surface of the cortex, it may incite the periosteum in its vicinity to a tremendous deposition of new bone. On the other hand, if it develops toward the inner side of the cortex, the new-bone formation may be more prominent on the medullary surface. Indeed, the major marrow cavity for some distance above and below the lesion may become obliterated by newly deposited bone.

Finally, one occasionally encounters an osteoid-osteoma which seems to begin in and remain largely restricted to the periosteum, provoking but little reaction in the underlying cortex. We have two cases of this kind, both relating to proximal manual phalanges.

### *Clinical Complaints and Findings*

The duration of complaints at the time of admission to the hospital ranged between a few months and a number of years. Histories of less than six months were the exception; of six months to two years, the rule; and of over two years, not common. No patient gave a history of difficulty dating back longer than four years.

Only ten of the thirty-three patients made any mention of possibly relevant trauma in their case histories. Some of these stated that the trauma had antedated the onset of the symptoms by weeks, months, or even years. The rest of them dated the onset of the complaints directly from the trauma. Altogether, it is difficult to come to any conclusive decision about the factor of trauma. Indeed, it was sometimes not even clear that the site of the osteoid-osteoma was actually that of the previous trauma.

The principal complaint was of pain, and it was this that consistently led the patients to seek medical attention. Occasional and mild at first, the pain had usually increased in persistence and severity and, at the time of admission, was often bad enough to interfere with sleep. (It seems of interest in this connection that a number of the patients reported relief from the pain for some hours after taking about ten grains of acetylsalicylic acid.) Local swelling was apparent in some instances,—particularly where the lesion was in a bone site not very thickly covered by soft tissue. Limping was complained of in a considerable number of the cases in which the lesion was in a lower-limb bone. Stiffness and weakness of the part were observed in some of the cases,—notably in those in which the lesion was near a joint. In no case was there a history of febrile episodes in connection with the lesion.

Physical examination revealed, in the majority of cases, some swelling and tenderness, localized to the general region of the pain. Indeed, these were often the only relevant findings. In some cases, on account of the fact that the part had been spared in use, there was also a slight amount of muscle atrophy. Local heat and redness were absent in all but one of the cases and were slight in that one. This is striking in view of the fact that, in a large majority of the patients, the condition had been interpreted



clinically as having an inflammatory basis, and, in particular, as being either chronic osteomyelitis or chronic bone abscess.

### *Clinical Diagnosis and Roentgenographic Findings*

Clinically, the diagnosis of osteoid-osteoma is not really very difficult, if one is familiar with it and the possibility of its presence is borne in mind. The history and physical examination alone often furnish the necessary cues. Specifically, one should suspect that it is present if: (1) the patient is an adolescent or a young adult; (2) the complaint is of well-localized bone pain of at least some months' duration; (3) this pain is not associated with local heat, although some local swelling may be present; and (4) the condition is not, and has not been, associated with bouts of fever.

The clinical laboratory findings shed no light upon these cases. The sedimentation rate of the red blood cells was within normal limits in the few cases in which it was determined. The blood count likewise failed to yield any significant findings. It goes without saying that most of the patients, in the course of the routine, were tested serologically for syphilis, with negative results. An intradermal quantitative tuberculin test was also done in many of the cases, for the sake of any additional information it might contribute toward the diagnosis, but was, of course, only of negative value.

It is the *roentgenographic picture* that constitutes the most valuable single diagnostic guide. However, this picture is very likely to be misinterpreted unless one is familiar with the possibilities as to the roentgenographic appearance of the condition. What one must remember particularly is that this picture has two aspects,—the manifestation of the osteoid-osteoma proper and that of the reaction which it has incited in the surrounding osseous tissue. The lesion itself is small, but the aura of reactive changes within which it appears may be quite extensive.

For some time in the course of its evolution, the osteoid-osteoma proper is usually indicated roentgenographically by a relatively radiolucent or rarefied area in the bone (Figs. 1, 7, and 11). This area is likely to be roundish in shape if the osteoid-osteoma is in spongy bone and oval if it involves the cortex of a long bone. Its greatest diameter is usually between five-tenths of a centimeter and two centimeters and is most likely to be about one centimeter. The reactively changed surrounding tissue appears as a more or less opaque or dense zone. This dense area of perifocal reaction may be only a narrow ring or it may spread for several centimeters about the lesion, even if the latter is in the spongiosa. If it is in the cortex of a long bone, the reactively densified area may extend for several inches both above and below the osteoid-osteoma proper. The densification of the cortex may also be found to extend for a considerable distance around the circumference of the affected shaft (Figs. 4, 7, 15, and 19).

Later in its evolution the osteoid-osteoma tends to become calcified and ossified. In harmony with this fact, its shadow no longer appears as an area of uniform rarefaction. Instead, it is opaque in some places and

may even be uniformly so. Thus, in a spongy-bone area, it eventually appears as a very radiopaque or dense circular nidus, which may, nevertheless, be made to stand out from the neighboring opaque bone by a narrow zone which is more permeable to the rays (Fig. 4). The same course is usually taken by an osteoid-osteoma when it is in the shaft cortex of a long bone (Fig. 19). In such a site, it is sometimes difficult, if not quite impossible, to trace out the opaque nidus representing the ossified osteoid-osteoma from the surrounding reactively thickened and densified cortical bone (Figs. 23, 24, and 25). The experience of Dr. M. M. Pomeranz, the roentgenologist of the Hospital for Joint Diseases, has shown that, under these conditions, overexposing the plate and taking the picture in various planes with a cone may enable one to recognize the lesion more readily.

The various shadows produced by the osteoid-osteoma and the reaction about it are open to misinterpretation. The usual error is to interpret the roentgenogram as reflecting some form of chronic inflammation of bone. Specifically, a film showing an area of rarefaction in the spongiosa, surrounded by an area of densification, is likely to be regarded as representing a chronic bone abscess with inflamed and sclerosed bone around it. Again, a film showing a radiopaque nidus in the spongiosa is likely to be interpreted as signifying an "annular sequestrum", surrounded by an area of chronic osteomyelitis. The picture produced by an osteoid-osteoma in the shaft of a long bone is most commonly mislabeled "chronic sclerosing non-suppurative osteomyelitis" or "osteomyelitis chronic from the beginning". On the other hand, should the examiner in such a case see a focus of rarefaction in the thickened and densified shaft cortex, he would be likely to misinterpret it as representing an intracortical abscess with inflamed bone around it. Other conditions with which an osteoid-osteoma of a long bone shaft has sometimes been confused include syphilitic osteoperiostitis and, even less plausibly, sclerosing osteogenic sarcoma. That these various roentgenographic diagnoses are untenable should be clear from a study of the history and clinical findings and is made obvious by the pathological findings in these cases.

In regard to diagnostic problems created by a special location of the lesion, mention should be made of the vertebral column. Specifically, it is extremely difficult to make the diagnosis of osteoid-osteoma when the lesion is in a facet or a lamina of a vertebral body. When the lesion develops under the articular cartilage of a long bone, particularly at the lower end of the femur or the upper end of the tibia, the case may be misinterpreted as one of osteochondritis dissecans.

#### PATHOLOGY

As stated, an osteoid-osteoma is of small size even when fully evolved, but it generally incites the tissue around it to an extensive reactive formation of new bone. The originally expressed conception of the lesion—a conception which we find no reason for changing—is, in brief, as follows:

The lesion is a benign osteogenic tumor of slow growth. The initial phase of its evolution in a given site seems to be the proliferation of the local bone-forming mesenchyme and particularly of its osteoblasts. Indeed, at an early stage, the tumor may consist largely of a vascular mesenchymal substratum, closely packed with osteoblasts, although showing also a scattering of osteoclasts (Fig. 30).

In the further evolution of the lesion, considerable intercellular substance develops between the osteoblasts. This substance becomes calcified only slowly, and consequently the tumor at this stage contains large patches of osteoid or numerous osteoid trabeculae (Figs. 5, 6, 13, 14, 17, and 18). In fact, the presence of rather large amounts of osteoid is so characteristic of the lesion at one stage in its evolution that the incorporation of the term "osteoid" into its name seems justified. Subsequently, the osteoid becomes calcified and converted into hypercalcified bone, which is neither typical fibrous bone nor typical lamellar bone. When fully evolved, the lesion is composed of compacted trabeculae of this atypical bone, the intertrabecular tissue of which is vascular and may still be rather cellular in some places. Ultimately, it is the osteoma rather than the osteoid aspect of the lesion that is conspicuous microscopically (Figs. 26 and 27). It should be noted, however, that there is no clear-cut correspondence between the age of the lesion, as represented by the patient's complaint, and the degree of calcification and ossification of the lesion, as observed grossly and microscopically.

We turn now to the pathology of the perifocal reactive response. An osteoid-osteoma developing in a spongy-bone area is found surrounded by a narrow zone of vascular connective tissue, which, in turn, is usually surrounded by an area of sclerotic osseous tissue. The trabeculae composing the latter are thick and irregular and interspersed with fibrous marrow (Fig. 2). In a shaft cortex, the perifocal sclerosis about an osteoid-osteoma is often particularly pronounced. Indeed, the bone cortex may be extremely thickened over a large area. The thickened cortex is found to be composed of two layers,—a layer of more or less transformed original cortex, and, on the surface of the latter, a layer of compacted, newly deposited periosteal bone. The osteoid-osteoma may be found abutting upon the medullary surface of the transformed original cortex, or lying between this layer and the layer of new cortex, or, finally, located entirely within new cortex (Figs. 12, 13, 16, 17, 20, 21, 24, 25, and 26). Microscopic examination, even when extensive and thorough, fails to reveal any infectious inflammatory basis for the perifocal sclerosis, whether the osteoid-osteoma has developed in spongiosa or in cortex.

However, why an osteoid-osteoma should arouse a perifocal osteosclerosis is by no means clear. Indeed, although we have given much thought to the question, we have at present only a presumptive answer for it. A factor in the explanation would seem to be the irritation of the bone-forming tissues by the slow, torpid growth of the lesion. The relatively greater freedom of growth provided by spongy bone, together with the

relatively meager bone-forming capacity of the latter, would seem to explain the generally milder character of the perifocal osteosclerosis when the osteoid-osteoma appears in spongy bone. On the other hand, when developing in cortex, the osteoid-osteoma sooner or later communicates its presence to the periosteum through direct or indirect irritation of the latter. The periosteum makes its characteristic response,—abundant deposition of new bone, accounting for the elaborate perifocal thickening of the cortex in the cortical cases. Incidentally, the pressure which the growth of the osteoid-osteoma creates upon the incasing spongiosa or cortex is undoubtedly the reason for the relatively mild but increasing and persistent pain which the patients in question suffer.

#### REPRESENTATIVE CASES

The paper published in 1935 contains a detailed description of each of the five original cases. None of these will be cited again here, and the reader is merely referred to them for the information which they already yield about osteoid-osteoma. Indeed, the twenty-eight additional cases contribute nothing fundamentally new to our original general conception of the disease. However, in other respects certain of the later cases have contributed further information. Specifically, as to the pathology, these cases include a few instances in which the osteoid-osteoma was in an even earlier stage of evolution than any described in the previous report. Notably, one case was encountered in which the lesion was as yet free of osseous tissue, even almost free of osteoid, and so rich in osteoblasts as to suggest what one might call an "osteoblastoma". As to localization, thirteen of the subsequent cases revealed that an osteoid-osteoma can develop in cortical bone and that spongy bone is thus not the only possible site of origin for the lesion. Furthermore, we have observed, in relation to phalanges, certainly one instance and possibly another in which the growth could be conceived as a subperiosteal osteoid-osteoma. More precisely, these were cases in which it affected the cortex only slightly, being largely confined between the periosteum and the cortical outer surface.

Taken together, the following case reports are intended to compose a representative picture of our present conception of osteoid-osteoma. The first two (like those originally reported) show spongy-bone localizations of the lesion at contrasting stages of its development. Specifically, the lesion in Case 1 was in a stage such that roentgenographically it was manifested as a small area of increased radiolucency, while in Case 2 it was evident as a nidus of radiopacity. Cases 3 to 7, inclusive, are intended to show how the lesion appears when developing in the shaft cortex of a long bone. In presenting five cases of this type, we do not mean to imply that this localization is the more common one, but are using them merely to emphasize an aspect of the condition of which we were not yet aware when the original paper was written. They include an instance (Case 7) in which, on account of the pronounced thickening and densification of the cortex and the ossification of the osteoma proper

within it, the lesion could not even be distinguished in the roentgenogram of the affected bone. Finally, Case 8 is presented to show what we conceive as a subperiosteal localization of osteoid-osteoma.

**CASE 1.** The patient was a man, twenty-three years old, who was admitted to the Hospital under the care of Dr. J. E. Milgram. His chief complaint was pain of seven months' duration in the left big toe. It was localized to the medial aspect of the distal phalanx of this toe and did not radiate. It was usually noticed only at night, but was then severe enough to wake the patient often. The pain could not be related to any previous trauma or illness, nor did it seem to be aggravated by walking, weight-bearing, or other activity. It was not associated with any local changes noticeable to the patient. Furthermore, he had no complaints referable to other parts of the body or to his general health. The local physical examination revealed merely a slight swelling of the medial aspect of the left big toe near the base of the distal phalanx. The area was exquisitely tender to pressure. There was a barely perceptible increase in local heat, but no local redness.

#### *Roentgenographic, Operative, and Pathological Findings*

The roentgenogram revealed a circular area of more or less increased radiolucency, four millimeters in diameter, occupying the proximal medial corner of the affected phalanx (Fig. 1). On the basis of the case history and the roentgenographic findings, Dr. Milgram suspected before operating that he was dealing with an osteoid-osteoma. He removed from the phalanx the corner bearing the lesion. Culture of a swabbing from the site of resection yielded the staphylococcus aureus and a micrococcus which grew out in twenty-four hours. It should be noted, however, that the swabbing could not have been from the osteoid-osteoma itself, since the latter was removed intact in its casing of phalangeal bone. Thus the bacteria cultured represented, in all likelihood, merely contaminating organisms, which, of course, are very likely to be culturable when the operative site is a toe. The wound was closed without drainage and healed by primary union. The patient was completely freed of his complaints and has remained so.



FIG. 1

**Case 1.** Roentgenogram revealing a barely detectable circular area of increased radiolucency occupying the proximal medial corner of the affected phalanx.

in the roentgenogram. Microscopically, this area (Figs. 2 and 3) showed numerous trabeculae and irregular patches of osteoid set in a substratum of highly vascular osteogenic connective tissue. Here and there, the osteoid appeared to have been undergoing calcification and conversion into atypical bone. The lesion showed a scattering, and in some places even aggregations, of osteoclasts. It appeared well set off from the perifocal bone, except in one place, where some of its trabeculae had fused with those of this bone. The intertrabecular marrow of the perifocal bone was abnormally fibrillar, and the bone trabeculae themselves seemed somewhat thickened.

**Summary:** To one familiar with the condition, the clinical aspects of this case should already suggest the possibility of osteoid-osteoma. To such a person, the roentgenographic findings would support this

diagnosis. Since the growth in this case had not yet undergone much calcification or ossification, the shadow cast by it was mainly one of rarefaction. However, the change noticeable in the roentgenogram was

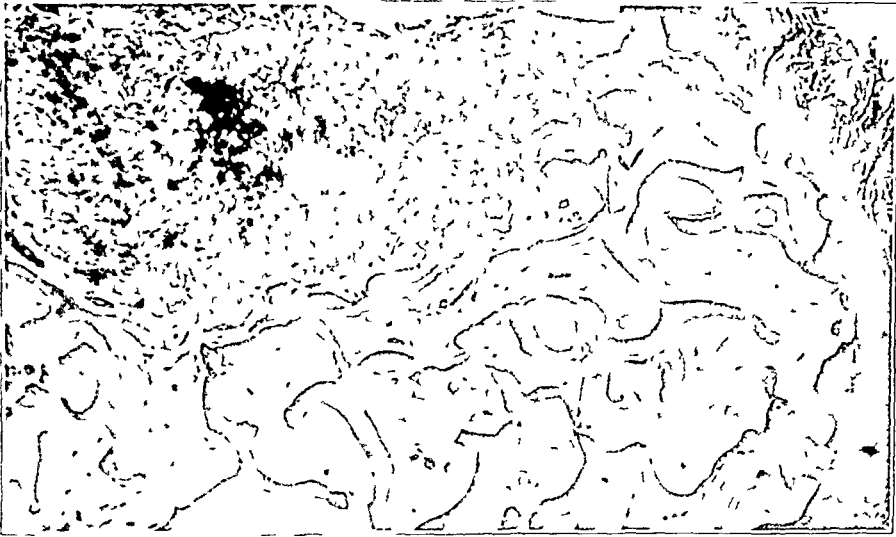


FIG 2

Case 1. Photomicrograph (low magnification) showing the osteoid-osteoma (upper left-hand quarter of the picture) standing out in contrast to the adjacent spongy bone. The trabeculae of the latter seem perhaps somewhat thickened, and the intertrabecular marrow, especially in the immediate vicinity of the osteoid-osteoma, is abnormally fibrillar. The darker, blurred patches in the center of the lesion represent areas of calcifying osteoid (Fig 3).

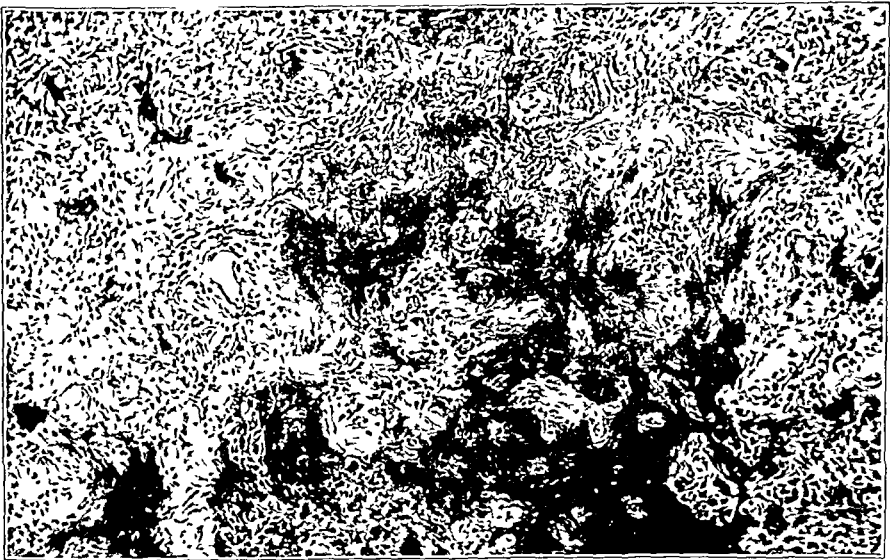


FIG 3

Case 1. Photomicrograph (medium magnification) showing details of the section in Fig 2, and specifically the calcified osteoid developing in a substratum of highly vascular osteogenic connective tissue.

slight and even rather vague. Indeed, if one did not bear in mind the possibility of osteoid-osteoma, this slight alteration could easily have been misinterpreted or even overlooked entirely.

**CASE 2.** The patient was a young man, nineteen years of age. Dr. D. R. Telson, to whom we are indebted for the data on the case, treated him at another institution. The patient's chief complaint was of pain. This was localized to a small area on the outer aspect of the left leg, near the knee joint. It had been present for nine months. It was intermittent and not severe, but often woke the patient at night. In addition, there was considerable local tenderness to pressure. However, there was no local heat, redness, or swelling. The patient gave no history of any possibly relevant injury or previous illness. On the basis of the clinical and roentgenographic findings, a diagnosis of localized chronic osteomyelitis with an "annular sequestrum" was made.

#### *Roentgenographic, Operative, and Pathological Findings*

The roentgenogram showed, in the head of the fibula toward its lateral surface, an approximately circular area of relatively increased radiopacity, about five-tenths of a centimeter in diameter (Fig. 4). This area was seen to be encircled by a narrow zone of relatively increased radiolucency, about one millimeter in width. It in turn was bordered, especially below and medially, by a rather wide area which was relatively radiopaque. Altogether, the roentgenographic appearance was interpreted as an area of chronic osteomyelitis in the head of the fibula, containing an "annular sequestrum" represented by the core-like area.



FIG. 4

**Case 2.** Roentgenogram showing, in the head of the fibula toward its lateral side, a small, roundish area of relatively increased radiopacity representing the osteoid-osteoma.

In operating on the patient, Dr. Telson found nothing noteworthy in the soft tissues overlying the lateral surface of the head of the fibula. In cutting a window into this surface, however, he encountered the core-like area and found that the latter could easily be lifted out of its bed. It was rather yellowish in color and gritty in substance. There was no pus or any other gross evidence of osteomyelitis. No material for culture was taken from the site of operation. The wound was closed without drainage and healed by primary union. The

patient was completely relieved of his preoperative complaints and has remained so.

Microscopically, the extirpated nidus of tissue (Figs. 5 and 6) was found to be composed of calcified osteoid and atypical bone, arranged in trabeculae and patches and interspersed with a highly vascular osteoblastogenic connective tissue. Here and there, osteoclasts were found abutting upon the trabeculae and patches of osteoid and bone.

**Summary:** This case is one in which the roentgenographic appearance alone should suffice to put one upon the track of the correct diagnosis. Specifically, the cue is given by the relatively opaque nidus standing out in a spongy-bone area. Except in connection with osteoid-osteoma, we have never seen the combination of a single nidus of this kind in a spongy-bone area with a history of persistent local pain and tenderness not associated with fever. It is true that one occasionally encounters acci-

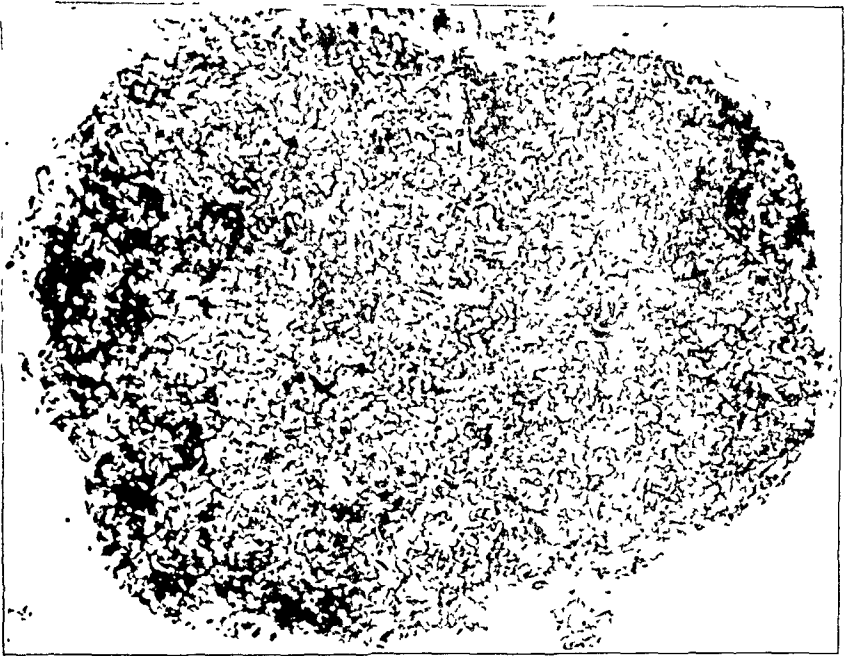


FIG. 5

Case 2. Photomicrograph (low magnification) showing a section through the entire lesion represented by the radiopaque area in the head of the fibula seen in Fig. 4.

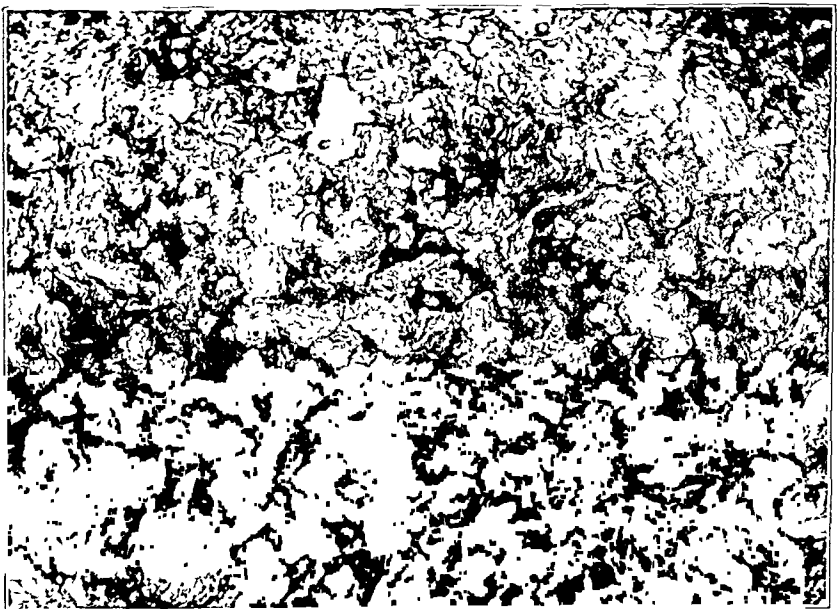


FIG. 6

Case 2. Photomicrograph (medium magnification) showing details of a small area of the section portrayed in Fig. 5. Note the osteoid and bone developing against a background of connective tissue.



dently, in roentgenograms of spongy-bone areas, a solitary core-like nidus not associated with any complaint. Under these circumstances, such a nidus represents an enostosis, which has formed in the spongiosa upon the basis of a developmental anomaly. Such enostoses, like the multiple ones in cases of osteopoikilosis, differ from osteoid-osteoma anatomically. More precisely, they differ in that they represent mere compactions of spongy trabeculae of otherwise normal histological structure.

CASE 3. The patient was a man, twenty-four years old, who was admitted to the Hospital under the care of Dr. M. M. Youmans. His chief complaint was of pain in the right forearm of almost two years' duration. The patient dated the onset of his difficulties from a wrench to the forearm. The alleged trauma was said to have been followed promptly by the appearance of ecchymosis on the affected forearm. This was associated with local pain and swelling, both of which persisted and even increased. The site of the swelling was sensitive to pressure. The pain was noticed mainly at night, and indeed frequently woke the patient, and it was exacerbated by damp weather. In spite of his complaints, he had continued to use the forearm at work. His general health had remained good, and he had had no fever in connection with the local condition.

The physical examination yielded entirely negative results, except in regard to the condition of the affected forearm. The latter showed a hard, firm swelling on the medial aspect of the middle third of the right ulna. This area was sensitive to pressure, and the pain was referred up and down the forearm. The skin over the swollen area was not reddened, although it felt somewhat warm. The condition did not interfere with supination or pronation of the forearm, and there was no loss of strength in the wrist or fingers.

Prior to the patient's admission to the Hospital, on the basis of the clinical and roentgenographic findings, the patient was held to be suffering from an abscess in the cortex of the right ulna. His surgeon, Dr. Youmans, consulted with us, however, and agreed with us that this diagnosis was untenable. He changed the diagnosis to osteoid-osteoma and advised the patient to submit to resection of the affected part of the ulna.

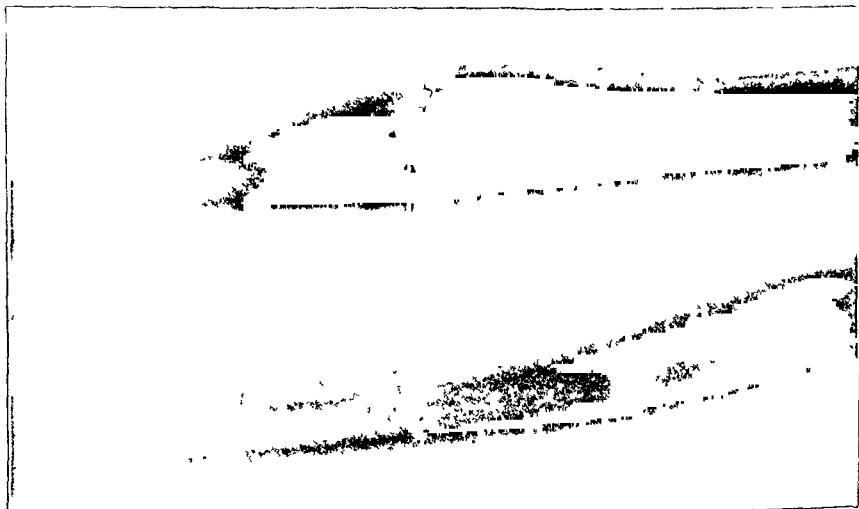


FIG. 7

CASE 3. Roentgenogram of the affected ulna showing thickening of part of its shaft in consequence of deposition of periosteal new bone. Note the lozenge-shaped area of rarefaction in the region of greatest cortical thickening.

*Roentgenographic, Operative, and Pathological Findings*

The roentgenogram of the affected ulna (Fig. 7) showed that its middle third was thickened for a distance of about seven centimeters. The thickening could be seen to have resulted from deposition of periosteal new bone, which was most abundant on the medial and posterior surfaces. In the region of greatest cortical thickening, a lozenge-shaped area of rarefaction, measuring one and twenty-five hundredths of a centimeter in length and seventy-five hundredths of a centimeter across, could be plainly seen. The medullary cavity in the area of involvement appeared also to be traversed by newly formed bone.

From the area of greatest cortical thickening, the surgeon removed a block of bone, three and five-tenths centimeters in length, one and five-tenths centimeters across, and seventy-five hundredths of a centimeter in thickness. On the inner surface of this block, toward one end, there was an oval hollow, filled with brownish-red and rather soft tissue (Fig. 8, A). The latter was adherent to the cortex.

After the cortical block was lifted out, it was seen that some brownish-red tissue still lay in a contiguous hollowed-out portion of the spongiosa, and culture swabbings were taken from this. This tissue, with some of the surrounding sclerotic spongiosa, was also curetted away. This hollow in the cortex and adjacent spongiosa and the brownish tissue which this hollow contained (Figs. 8, B and 8, C) represented the area which cast the shadow of rarefaction in the preoperative roentgenogram.

The swabbings, cultured aerobically and anaerobically, remained sterile. The wound was closed without drainage, and healing took place by primary union. Two days after the operation, the pain for which the patient was admitted had disappeared, and it has not returned since.

A number of slivers, several millimeters in thickness, were cut from the cortical block and sectioned for histological study. As a matter of course, the tissue curetted from the medulla was also submitted for such study. A fragment of the brownish-red tissue was even embedded and sectioned without decalcification, so that we could judge to what extent osteoid was present in it.

Microscopically, the sections prepared from the thickened cortex with brownish-red tissue attached showed the latter to be composed of a highly vascular osteoblastic connective tissue, containing numerous delicate trabeculae of osteoid (Figs. 9 and 10). These were found lined by osteoblasts and also, in some places, by osteoclasts. The mass of osteoid tissue was clearly delimited from the overlying cortex. The latter, although thickened by periosteal new-bone deposition, showed a spongy structure in its deeper portion. The spaces in the spongy cortex contained fibrofatty marrow, which was continuous with the osteoblastic connective tissue containing the osteoid trabeculae.

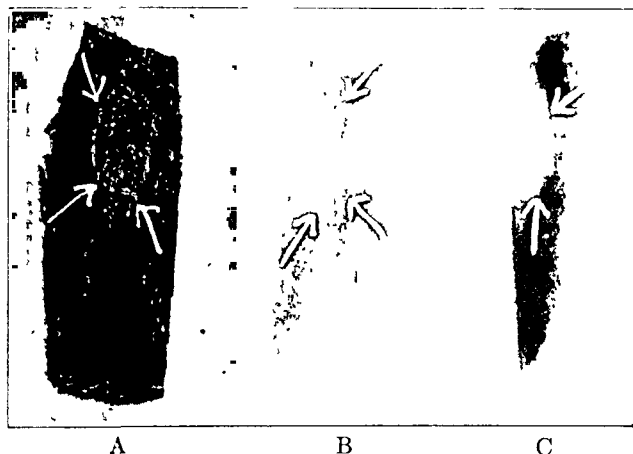


FIG. 8

Case 3. A: Photograph of the block of bone resected from the ulna shown in Fig. 7. Note, at the upper end, the hollow on the inner surface occupied by the osteoid-osteoma, which appears as a globular mass of darker looking tissue and which was found to be rather soft and brownish red on gross examination.

B and C: Roentgenograms showing this block laid flat and on end, respectively. Note that the hollow and the tissue it contains represent the rarefaction shadow shown in Fig. 7.

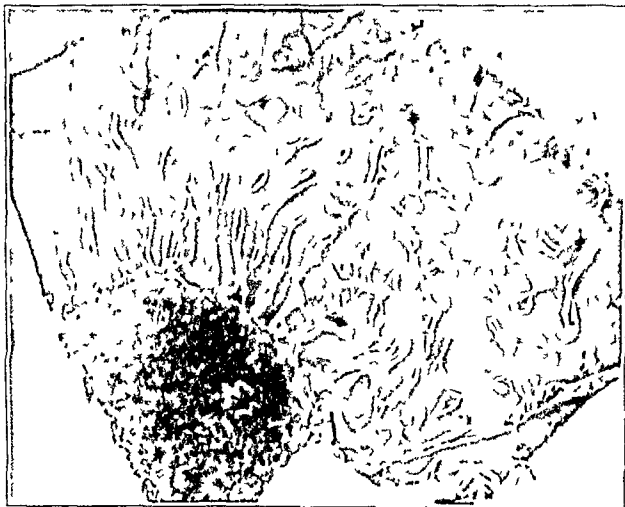


FIG 9

osteoma developing in the shaft of a long bone. For almost two years, the condition had been erroneously regarded as a sclerosing osteomyelitis of the ulna, and the rarefaction shadow in the affected area had been misinterpreted as an abscess cavity. Actually there was no cavity at all, there

FIG 9

Case 3 Photomicrograph (low magnification) showing, in cross section, the thickened cortex of the ulna, with the osteoid-osteoma attached on its medullary surface. Note that the cortical bone is somewhat rarefied and that the osteoid-osteoma is well differentiated from it.

Nowhere was there any evidence of active inflammation or any sign that an active inflammation had ever been present.

*Summary:* This is an instance of osteoid-

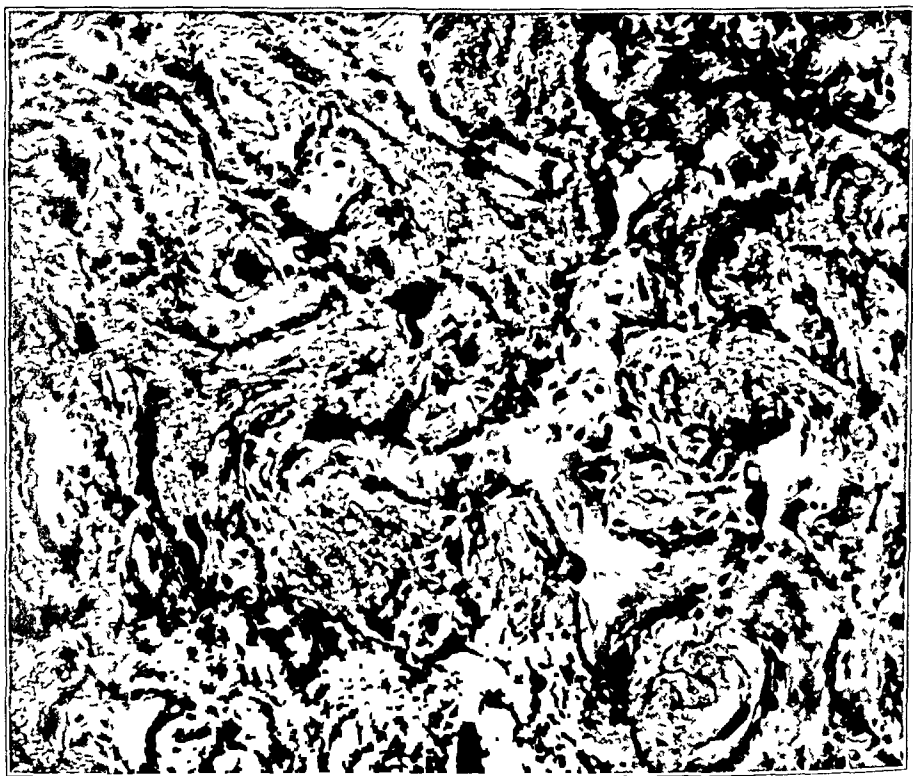


FIG. 10

Case 3 Photomicrograph (medium magnification) showing histological details of the osteoid-osteoma seen in Figs. 8, A and 9. Note that the lesion is composed of trabeculae of osteoid, which are lined by osteoblasts and in some places by osteoclasts. The osteoid is developing in a very vascular connective tissue.

being merely a hollow filled with connective tissue and osteoid and surrounded by thickened cortex and sclerotic spongiosa. It is interesting also that, despite the fact that the affection had been present for almost two years, the nidus of connective tissue and osteoid had not undergone much calcification and transformation into atypical bone, as it does in most cases.

CASE 4. The patient was a girl, sixteen years of age, who was treated at the Hospital on the Service of Dr. S. A. Jahss. About one and one-half years before admission, she had begun to experience nocturnal pain, in the right knee. It was severe enough to interfere occasionally with sleep. Several months afterward, she had begun to experience, in addition, a dull, steady pain in the right groin, and this pain, too, was at first noticed only at night. The pain in both sites became progressively worse, and, about eleven months before admission, was felt during the day as well as at night. However, it was worse at night, and it gradually became severe enough to make the patient limp occasionally. Despite the pain and the limp, she remained fairly active and continued attendance at school, since she found that rest did not lessen the pain. Nevertheless, she did lose twenty pounds in weight during the one and one-half years following the onset of her difficulty. On questioning the patient, it was also found that the onset and progress of the condition had not been associated with fever or chill or any previous trauma.

On physical examination, Dr. Jahss found very slight atrophy of the right thigh, more obvious when viewed from the rear. There was no limitation of mobility either at the hip joint or at the knee joint. The medial aspect of the right thigh, two or three inches below the inguinal ligament, was moderately tender to pressure. However, there was no local heat, redness, or induration. On the basis of the clinical and roentgenographic findings, it was suspected that the patient was suffering from an osteoid-osteoma of the upper portion of the shaft of the femur, at the level of the lesser trochanter.

#### *Roentgenographic, Operative, and Pathological Findings*

The preoperative roentgenogram (Fig. 11) revealed a roundish, rarefied area, seventy-five hundredths of a centimeter in diameter, situated in the anterior part of the femoral shaft, at the level of the lesser trochanter. On one surface, the rarefied zone abutted against the inner surface of the cortex. There was a wide perifocal zone of densification evidently reflecting reactive sclerosis of the spongiosa about the rarefied area, and also of the overlying cortex. The roentgenologist, Dr. M. M. Pomeranz, concurred in the impression that we were dealing here with an osteoid-osteoma.

The surgeon removed a block of thickened cortex from the diseased area on the anteromedial side of the femur, in the vicinity of the lesser trochanter. The exposed underlying spongiosa was also found to be sclerotic. At operation, culture swabbings were taken from the inner surface of the cortical specimen and adjacent spongiosa, which was then curetted. The swabbings were cultured aerobically and anaerobically and remained sterile. The wound was closed tightly and healed by primary union. Within forty-eight hours after the operation, the patient was completely relieved of the preoperative pain of long standing.

The resected cortical block measured about three centimeters in length, two centimeters in width, and a little more than one centimeter in depth at the thickest point. The thickening had obviously resulted from periosteal new-bone deposition. On the medullary surface of the block, a round, reddish mass of rather granular and gritty tissue was observed (Fig. 12, A). It measured about five-tenths of a centimeter in width. The block was cut into several slivers, and these showed that it extended for about the same distance into the cortex, toward the periosteum. The nidus was apparently the principal source of the rarefaction shadow seen in the preoperative roentgenogram (Fig. 12, B).

Microscopically, the nidus of granular and gritty tissue in question (Figs. 13 and 14) was found to be composed of trabeculae of osteoid and atypical bone, set against a background of osteoblastogenic connective tissue. The trabeculae were lined by osteoblasts, and in some places had osteoclasts abutting upon them. The substratum of connective

tissue was rather vascular. In many places its spindle-shaped cells could be seen to have undergone transformation into osteoblasts. Where this had occurred, there was excess intercellular material, so that the total picture presaged the formation of osteoid trabeculae. Much of the cortex overlying the lesion clearly represented newly deposited periosteal bone. The thickened cortex and the lesion proper were plainly delimited. Nowhere in the many slides prepared from the specimen was there any evidence of infection or inflammation.

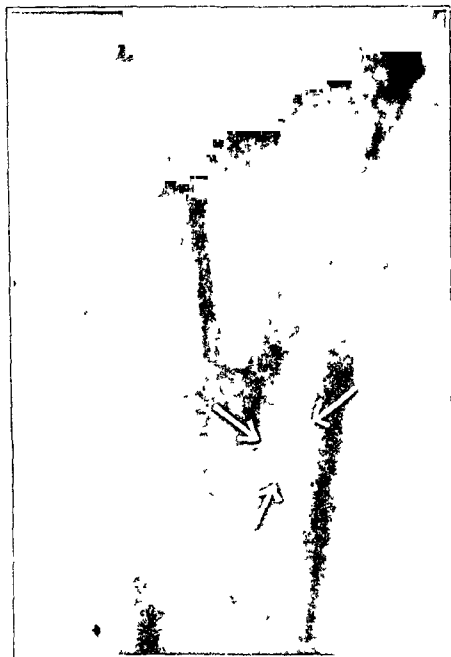


FIG. 11

CASE 4. Roentgenogram showing a roundish, rarefied area situated in the femoral shaft at the level of the lesser trochanter.



FIG. 12

CASE 4. A: Photograph of a slice cut from the resected cortical block through the area containing the osteoid-osteoma. Note the latter on the medullary surface, . . . . . rtical tissue.

. . . . . of this same slice laid flat, showing a more or less roundish, rarefied area, representing the osteoid-osteoma in the cortex.

*Summary:* This is a case of osteoid-osteoma developing in the shaft cortex of the upper end of the femur. However, the roentgenograms in this case would be likely to be reported as showing either a chronic osteomyelitis or an abscess of the upper end of the femur. The sterility of the cultures, the absence of evidence of inflammation in the sec-

tions studied microscopically, the healing by primary union, and the dramatically prompt cessation of the previously stubborn pain exclude an inflammatory lesion and are characteristic of osteoid-osteoma.

CASE 5. The patient was a man, twenty-four years of age. Dr. A. Kenin, to whom we are indebted for the material and data on this case, treated him at another institution. The patient's chief complaint was of pain, which was localized to the outer aspect of the upper end of the right femur, just a little below the greater trochanter. The patient stated that the pain had been present since he fell off a stool four months before. It was intermittent and not severe on the whole, although it sometimes woke him at night. In addition, there was considerable local tenderness to pressure. However, there was no local heat or redness, and no thickening of the affected bone region was noted by palpation. On the basis of the clinical and roentgenographic findings, Dr. Kenin suspected that he was dealing with an osteoid-osteoma arising in the shaft cortex of the upper end of the femur.

#### *Roentgenographic, Operative, and Pathological Findings*

In the roentgenogram of the affected femur (Fig. 15) it was noted that, for about seven centimeters below the greater trochanter, the cortex was thickened laterally. The



FIG 13

Case 4 Photomicrograph (low magnification) showing a section prepared from the slice of tissue described under Fig 12. Note the osteoid-osteoma set in, but clearly differentiated from, the adjacent thickened cortex. The latter consists largely of relatively new bone of periosteal origin. The more compact osseous tissue in the lower left-hand corner represents original cortical bone.

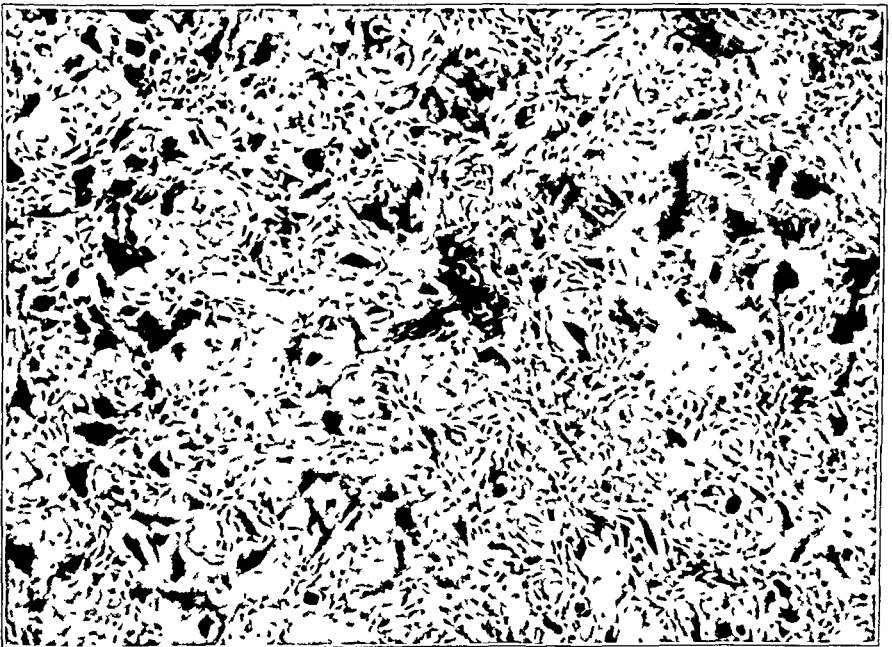


FIG 14

Case 4 Photomicrograph (medium magnification) showing histological details of a portion of the osteoid-osteoma. Note that osteoid and trabeculae of atypical bone are developing in a substratum of rather vascular osteoblastogenic connective tissue containing a scattering of osteoclasts.

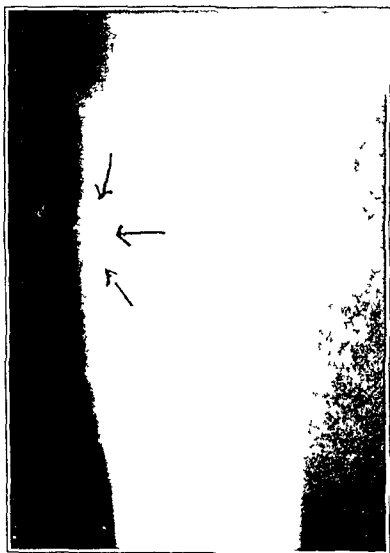


FIG. 15

Case 5. Roentgenogram showing thickening of the femoral cortex for some distance below the greater trochanter. Near the upper end of the thickened cortex, there is a small lozenge-shaped area of rarefaction.

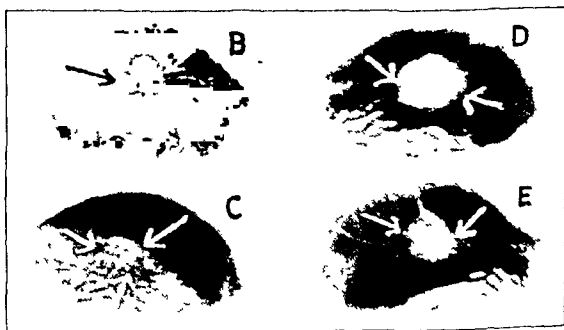


FIG. 16

Case 5. A: Roentgenogram of the resected block. Note that the area of rarefaction shows a sort of opaque ring within it.

B: Photograph of one of three transverse slices of bone cut from the resected block through the area of rarefaction. Note that the latter corresponds to a circular nidus (the osteoid-osteoma), which is situated in the zone between the original and the newly deposited cortical bone.

C, D, and E: Roentgenogram of these three slices, also laid flat. Note that in C the area corresponding to the osteoid-osteoma is barely distinguishable, while in D it is very clear and in E it is again less clear. This is so because at D the osteoid-osteoma ran through the whole thickness of the slice, while at C and E it did not.

thickening had taken place through deposition of new bone on the periosteal surface of the cortex, the outline of the medullary canal showing no obvious modification. Near the upper end of the thickened part of the cortex, there was a small, lozenge-shaped area of rarefaction, about one centimeter in its long axis and five-tenths of a centimeter in its transverse axis. This rarefaction was also manifest, although in a more rounded form, in the roentgenogram of the femur taken at an oblique angle.

A block of bone, representing most of the affected area and measuring about five centimeters in length, two and five-tenths centimeters across its widest portion, and one and five-tenths centimeters across its thickest part, was submitted for study. It was found to be composed mainly of thickened cortex, which the surgeon had difficulty in cutting through with bone chisels. The underlying medullary cavity was found not to be obliterated. No culture swabbings were taken from the site of operation. The wound was closed tightly without drainage, and healing took place by primary union. Within a few days, the patient was completely free of his preoperative complaints, and he has remained so.

The resected block was laid flat and x-rayed, and in the roentgenogram (Fig. 16, A) the area of rarefaction showed some details which had not been visible in the preoperative roentgenograms. The block was then sliced transversely into sections about five millimeters in thickness. These sections showed that the area of rarefaction (one centimeter by five-tenths of a centimeter) repre-

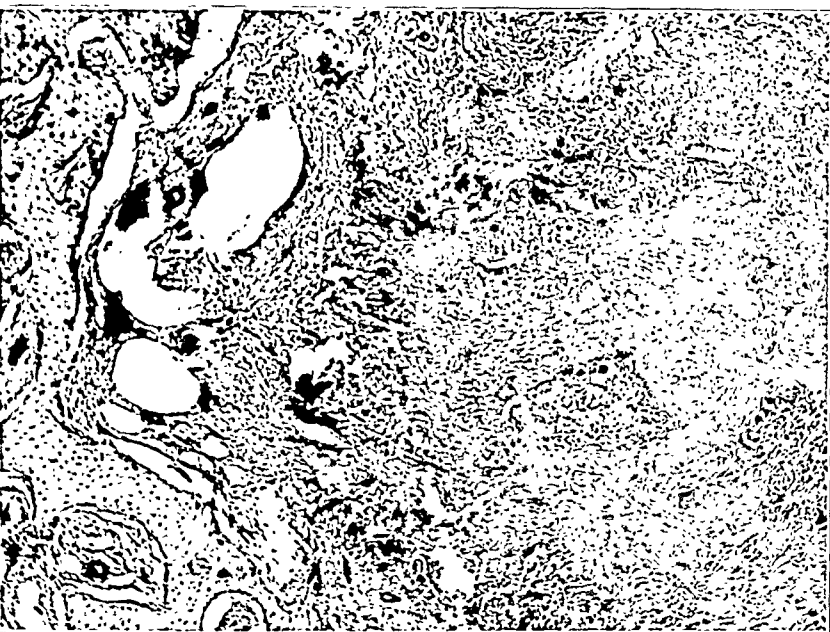


FIG. 18

Case 5. Photomicrograph (medium magnification) showing histological details from the uppermost tip of the osteoid-osteoma as pictured in Fig. 17. Note that the lesion is composed of large plaques of calcifying osteoid, which has developed in a substratum of osteoblastic connective tissue.



FIG. 17

Case 5. Photomicrograph (low magnification) showing a section prepared from the slice of bone pictured in Fig. 16, B. Note that the osteoid-osteoma is clearly differentiated from the incasing cortical bone. Note also the cement line running roughly across the middle of the section and demarcating the original cortex below from the new cortical bone above.



sented a calcifying nidus, reddish at its periphery and whitish at its center (Fig. 16, *B*). It was situated in the zone between the original and the newly deposited cortical bone, and extended about equally into both. A roentgenogram of the slices of bone containing the nidus showed even more details (Figs. 16, *C*, 16, *D*, and 16, *E*). It revealed even more clearly that the nidus was situated between the old and the new cortical bone and that the thickening of the cortex was to be accounted for largely, if not exclusively, by periosteal new-bone deposition.

All of the blocks were embedded and sectioned for detailed histological study, and serial sections were prepared from those containing the nidus. The latter (Fig. 17) could clearly be seen to be embedded between the original and the newly deposited cortical bone. Large areas were composed of trabeculae and patches of calcifying osteoid and atypical bone (Fig. 18). Interspersed between these, and elsewhere also, there was vascular osteoblastogenic connective tissue. In many places in this bone-forming connective tissue, intercellular collagenous substance was present, indicating the first stages of osteoid formation. Osteoclasts were observed scattered through the lesion.

The nidus as a whole was clearly delimited from the surrounding cortical bone. Here and there, however, a trabecula at its periphery fused with this bone. The adjacent original cortical bone showed enlargement of many of its vessel canals, which contained a fatty fibrillar marrow. The few spongy trabeculae inserted in it were not thickened, although the intertrabecular marrow was also fibrofatty. The newly deposited periosteal bone adjacent to the nidus also presented large vessel spaces, containing an even more fibrous marrow. The condition of bits of periosteum attached to the outer surface of the sections showed that this tissue had undergone fibrous thickening. In the sections of the cortical blocks from areas above and below the nidus, the changes present were of the same order, though less severe. Nowhere (in the periosteum, cortex, or nidus itself) in the great numbers of sections examined was there any evidence that active inflammation was or had been present.

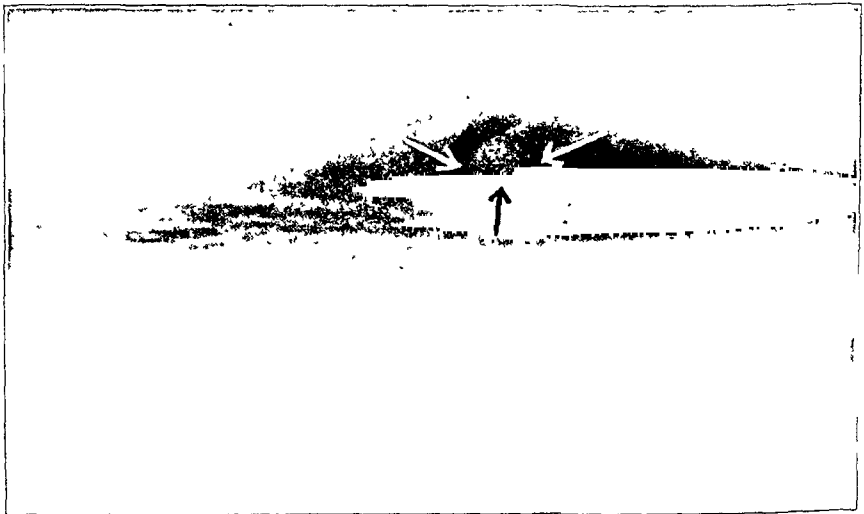


FIG. 19

Case 6. Roentgenogram showing a hump-like thickening of the tibial cortex, with a small, roundish focus in the middle.

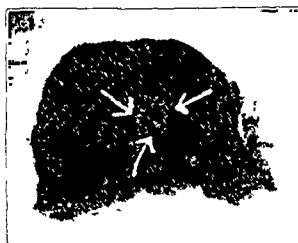


FIG. 20

FIG. 20

Case 6. Photograph of a transverse slice of bone cut from the resected cortical block through the area containing the focus shown in Fig. 19. This focus (the osteoid-osteoma) stands out fairly well in contrast to the adjacent bone.

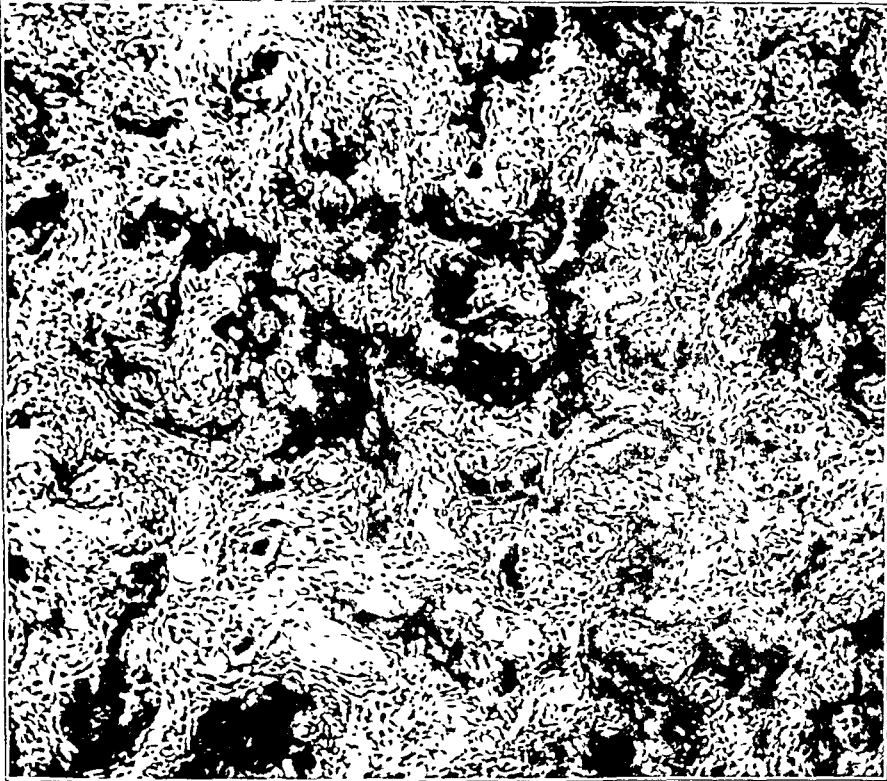


FIG. 22

Case 6. Photomicrograph (medium magnification) showing histological details of the osteoid-osteoma. Note the trabeculae of atypical bone set against a background of connective tissue.

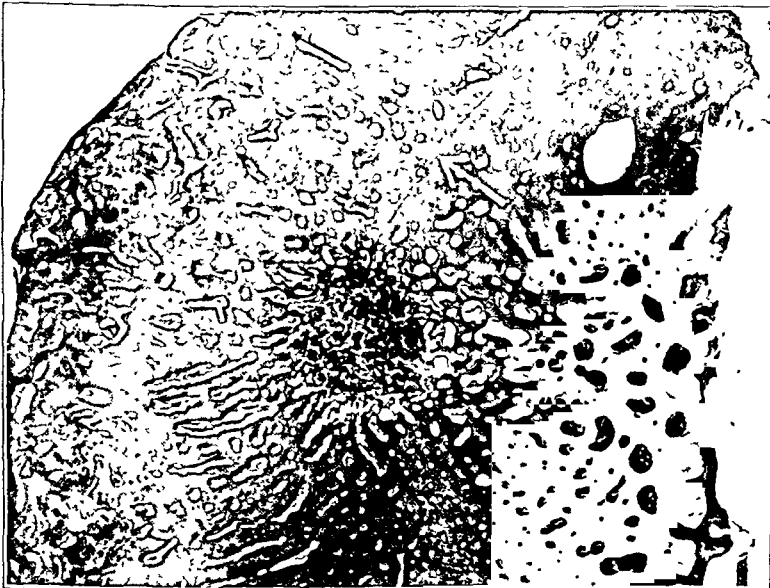


FIG. 21

Case 6. Photomicrograph (low magnification) of a section prepared from the slice shown in Fig. 20. Note the faint cement line arching across the section (more distinct on the right). The osteoid-osteoma lies approximately half above and half below this line. The latter represents the cleavage between the old cortical bone below and the newly deposited bone above.

*Summary:* This is a case of osteoid-osteoma in the shaft cortex of a long bone, in which the growth was entirely intracortical and specifically was situated between the original and the newly deposited cortical bone. Although the condition was of relatively brief standing so far as clinical complaints were concerned, much of the osteoid had already become calcified or had already been converted into atypical bone. Nevertheless, the osteoid-osteoma itself showed up in the preoperative roentgenograms as a rarefaction shadow. Such a shadow has ordinarily been misinterpreted as representing a cortical-bone abscess, which clearly it was not.

**CASE 6.** The patient was a girl, eighteen years of age, who was treated at the Hospital on the Service of Dr. Harry Finkelstein. Ten months before admission, she had noted the gradual onset of a dull, boring pain over the region of the mid-shaft of the left tibia on the medial surface. At first the pain had been intermittent, but in the course of some months it began to recur more and more frequently, until it became constant. The pain did not radiate and was not associated with numbness or sensory changes. The patient's general health was good, and the development of the local disorder was not associated with any special trauma or with fever. There were no complaints referable to any part of the body other than the left lower extremity.

Physical examination revealed slight atrophy of this extremity. However, there was no limp or limitation of motion. Deep palpation of the middle of the shaft of the tibia posteriorly revealed a vaguely delimited area of thickening, which was very tender to pressure. On the basis of the clinical and roentgenographic findings, it was already suspected before the operation that the patient was suffering from an osteoid-osteoma of the tibia.

#### *Roentgenographic, Operative, and Pathological Findings*

In the roentgenogram (Fig. 19) the cortex of the mid-shaft of the tibia showed a hump-like thickening along a distance of eight centimeters. The thickening had clearly resulted from periosteal new-bone deposition. At the crest of the hump, the cortex was nearly two centimeters thick. Almost exactly in the center of the thickened area, between the old and the newly deposited cortical tissue, there was a very small, roughly circular area of rarefaction, in turn containing a denser area. The outline of the major marrow cavity was preserved, and no new bone was apparent within it.

The surgeon resected a block of cortex, including the entire area of thickened tibia just described. The underlying medullary cavity was found not to be obliterated. Culture swabbings were taken from both the periosteal and the medullary surfaces of the block. The cultures from the periosteal-surface swabbings remained sterile, while those from the medullary-surface swabbings grew out a pathogenic staphylococcus aureus. It should be noted, however, that in taking these swabbings one could not have touched the area represented by the rarefaction shadow, since this area was buried deep in the thickened cortex (Fig. 20). It was concluded that the bacteria cultured were of extraneous origin. Indeed, within a few days, there was high fever, and when the wound, which had been tightly closed, was opened, the staphylococcus aureus and the streptococcus hemolyticus were cultured from the pus in it. Still worse, a few days later, the leg showed evidence of a gas-bacillus infection, and Welch's bacillus was also cultured from the pus. Clearly, then, the entire postoperative course in this case was one indicative of an imposed infection.

The block of bone removed at operation measured eight centimeters in length, two and five-tenths centimeters across at its widest point, and one and seventy-five hundredths centimeters through at its highest point. It was composed of cortex showing a hump-like thickening. When cut across, the thickened cortex showed, well within its substance, a somewhat eccentrically placed ossified nidus, measuring three millimeters in

transverse diameter and probably no more than four millimeters in lengthwise diameter. This focus corresponded to the area of rarefaction also observed in the preoperative roentgenogram.

Microscopically, this nidus (Figs. 21 and 22) was found located at a point on the line of juncture between the old and the newly deposited cortex. It was clearly delimited from the neighboring osseous tissue, although at its periphery some of its trabeculae had attached themselves to this tissue. The nidus consisted of irregular, thick trabeculae of atypical bone set in a substratum of osteoblastogenic connective tissue. The latter was only moderately vascular. The perifocal bone showed fairly large vascular spaces, containing connective-tissue elements in moderate amount. Nowhere in the lesion or in the perifocal bone was there any evidence of inflammation or infection.

*Summary:* This is a case of osteoid-osteoma developing in the shaft cortex of the tibia. The clinical and roentgenographic findings adequately suggest this. Hitherto, a case of this type would most commonly have been considered as one of sclerosing non-suppurative osteomyelitis, or osteomyelitis chronic from the beginning. The infection which set in after the operation represents an unfortunate complication. Nowhere in the sections studied microscopically could any indications of preexisting infection be found.

**CASE 7.** The patient was a girl, ten years of age, who was admitted to the Hospital under the care of Dr. D. R. Telson. She stated that, about one and one-half years before, she had fallen from a tree and sprained her right ankle, but that the pain and swelling associated with the fall had disappeared in the course of a week. For about a year afterward, she apparently had had no difficulty referable to this part. For seven months before admission, however, she had again been complaining of pain in the right leg and foot. This pain had set in abruptly, without immediate cause. It was dull and aching in character and radiated to the knee. At first it was intermittent and worse at night. Recently, it had also been bothering her during the day. She had no other complaints relevant either to bones and joints or to her general health. She had not felt feverish and had not lost weight.

The general physical examination yielded no remarkable findings, and even the right

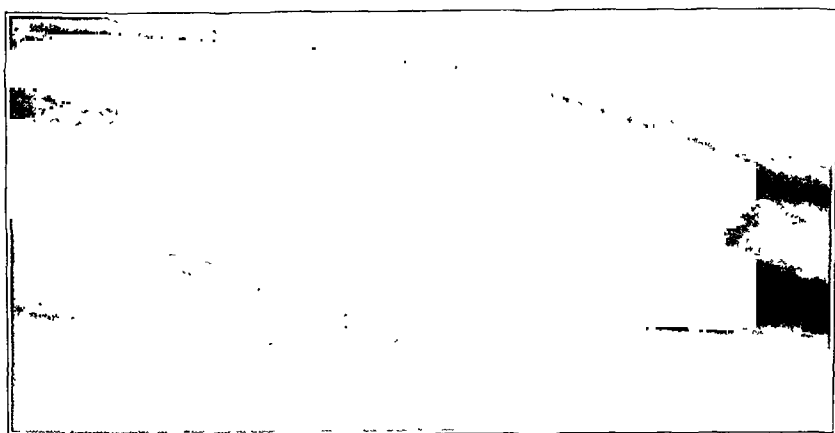


FIG. 23

**Case 7.** Roentgenogram showing fusiform enlargement of part of the tibia. In the affected region, the cortex is thickened, and the major marrow cavity appears largely filled in. Note that no annular or lozenge-shaped area of rarefaction or opacity is apparent in this roentgenogram.

lower limb showed no obvious abnormalities. Specifically, the affected foot and ankle revealed no swelling, discoloration, or increased local heat. Palpation did elicit some tenderness to direct pressure on the tibia posteriorly and above the medial malleolus. However, there was no muscle atrophy, and articular function was intact. Having profited by his experience in another case, Dr. Telson suspected that he might be dealing with an osteoid-osteoma, and this case proved to be very instructive, especially from the roentgenographic point of view.

#### *Roentgenographic, Operative, and Pathological Findings*

The preoperative roentgenogram (Fig. 23) revealed that the middle third of the tibia, over a distance of about ten centimeters, had become thickened. The thickening was due to periosteal new-bone deposition and was most pronounced on the posterior and

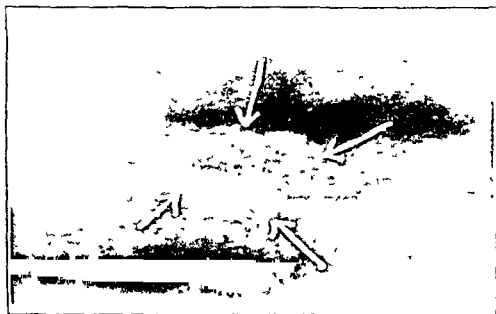


FIG. 24

Case 7. Roentgenogram of block of bone as resected. Note that a faintly delineated, lozenge-shaped area, which was not visible in Fig. 23, can now be detected.

lateral aspects, the bone in the region in question appearing more or less fusiform. The outline of the medullary cavity in the affected region could still be traced, but the cavity seemed also to contain considerable new bone. What the roentgenogram failed to show (it is true that none of the plates were over-exposed) was the presence of an annular or lozenge-shaped area of rarefaction or of opacity, such as, in view of experience with other cases, would have given support to the clinical diagnosis of osteoid-osteoma. However, such a shadow was visible in some of the serial slivers cut from the block of bone removed at operation.

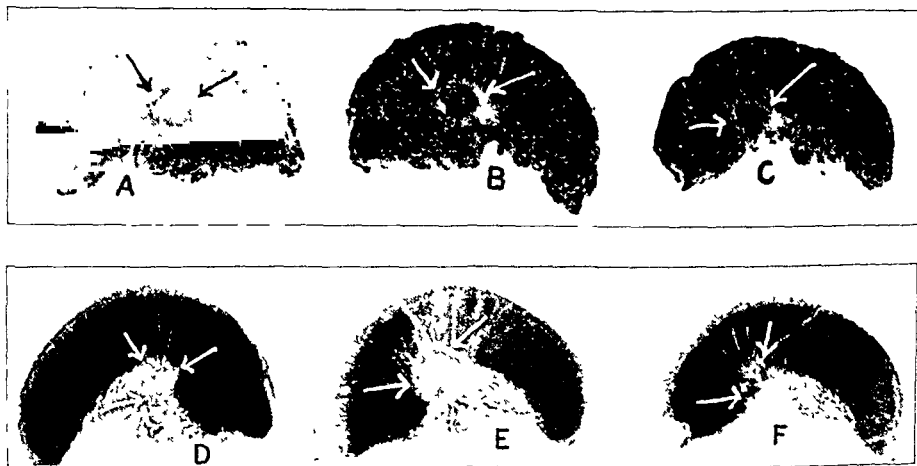


FIG. 25

Case 7. *A, B, and C:* Photograph of the three transverse slices cut from the resected block through the region of the lozenge-shaped area seen in Fig. 24. Note, in each sliver, the circular core (the osteoid-osteoma) situated on the medullary side of the cortex.

*D, E, and F:* Roentgenogram of these three slices in the same order. In *D*, the osteoid-osteoma shadow is rather faint; in *E*, it stands out clearly; and in *F*, it is only barely perceptible. The clarity of the focus in *E* is due to the fact that the lesion extended through the entire thickness of that sliver. In the other slivers it did not go all the way through and is correspondingly less plain.

This block consisted of a good portion of the middle third of the posterior half of the tibia. Culture swabbings were taken from the site of the osteotomy, but these remained sterile. The wound was closed without drainage and healed by primary union. The patient was in the Hospital for about two weeks, and for several days before her discharge she was free from the pain for which she had been admitted.

On gross examination, the piece of bone removed was found more or less pointed at

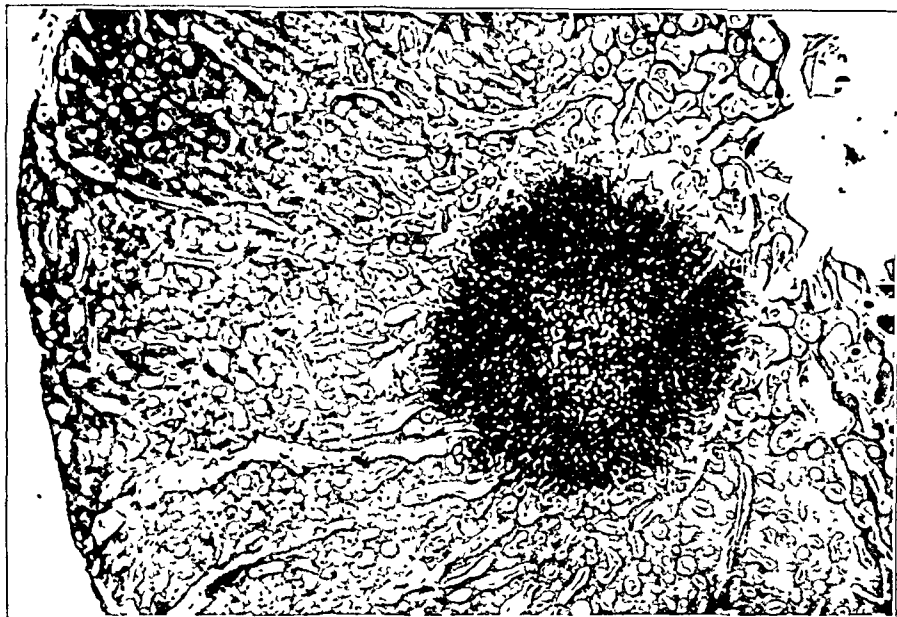


FIG. 26

Case 7. Photomicrograph (low magnification) showing the osteoid-osteoma situated deep in the cortex and standing out clearly in contrast to the surrounding cortical bone.

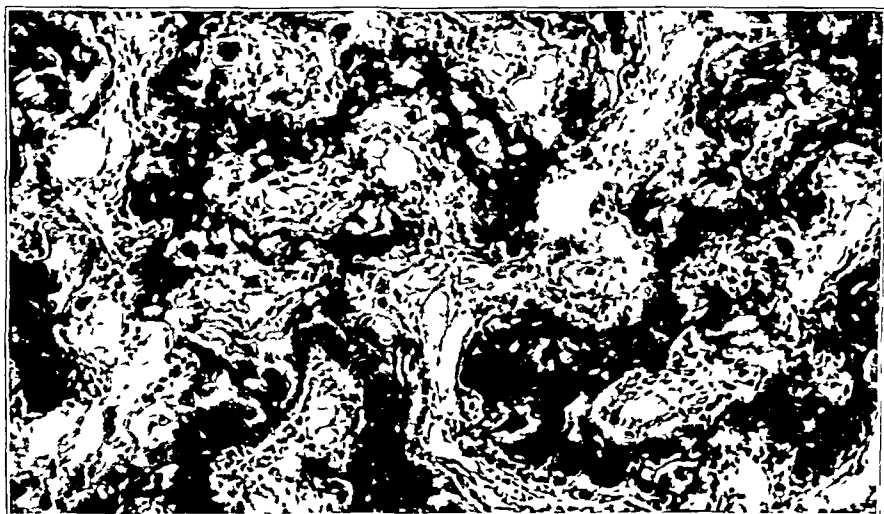


FIG. 27

Case 7. Photomicrograph (medium magnification) of the lesion shown in Fig. 26. Note the compacted trabeculae of highly calcified atypical bone comprising the lesion at this advanced stage.



FIG. 28

Case 8. Roentgenogram showing a periosteal osteoid-osteoma represented by the roundish protuberance attached to the phalanx.

course, in the two adjacent slivers, in which it did not extend through the entire thickness.

Microscopically, the nidus was found to be composed of compacted trabeculae of highly calcified atypical bone (Figs. 26 and 27). In stating that the bone was atypical, we mean that histologically it resembled neither typical fibrous bone nor typical lamellar bone. Many of the trabeculae were lined to a large extent by osteoblasts. Where a lining of osteoblasts was absent, osteoclasts and Howship's lacunae could be found abutting upon the trabeculae. Between the latter there was a fairly vascular connective-tissue stroma.

At its periphery, the nidus was for the most part clearly delimited from the adjacent cortex on the one hand and the spongiosa on the other. Here and there, however, an occasional trabecula of the nidus was becoming adherent to the perifocal bone. The perifocal cortical bone was more or less spongy, and the enlarged vessel spaces contained fibrofatty marrow. Furthermore, the line of demarcation between the newly deposited and the original cortical bone was not sharp. The perifocal spongy bone also presented a fibrofatty intertrabecular marrow.

*Summary:* This is a case of osteoid-osteoma arising in the shaft cortex of the tibia of a child. It developed in the medullary surface of the cortex. The reactive thickening which it provoked in the cortex was pronounced and widespread. It was because the ossified nidus representing the osteoid-osteoma was overshadowed by the thickened cortex that this nidus failed to stand out in the preoperative roentgenogram and was only discovered on serial slicing of the resected block.

both ends and roughly hemicylindrical in its mid-portion. In this region, the cortex measured from eight to ten millimeters in thickness. In an effort to bring out details which the preoperative roentgenogram had failed to reveal, the excised block was first x-rayed as a unit. Only the barest outline of the core which we were looking for was made apparent in this way, however (Fig. 24). The block was then sliced transversely into serial slivers, each of which was about eight millimeters in thickness. In three of these slivers a core stood out (Figs. 25, A, 25, B, and 25, C). It was situated on the medullary side of the cortex, was circular in outline, and measured about five millimeters in its transverse diameter. From its appearance in the successive slivers, it was further estimated that the core extended about one and five-tenths centimeters vertically. It consisted of a highly ossified nidus of bone, which was delimited from the neighboring cortex and spongiosa by a narrow zone of injected tissue. When these slivers were x-rayed (Figs. 25, D, 25, E, and 25, F) the focus stood out extremely well in the sliver in which it was present throughout the whole thickness, and less clearly, of



FIG. 29

Case 8. Photomicrograph (medium magnification). Note that the osteoid-osteoma has a substratum of osteogenic connective tissue, containing trabeculae of bone and osteoid, and that it is covered by periosteum, beneath which is a thin shell of bone.

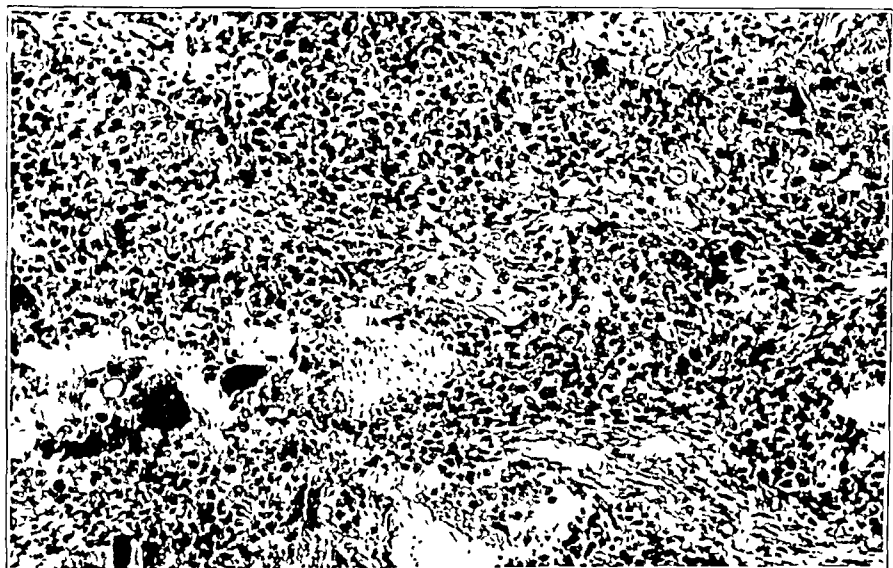


FIG. 30

Photomicrograph (medium-high magnification) from a case of osteoid-osteoma in which many portions of the lesion still showed pronounced cores of proliferating and compacted osteoblasts. In other areas, some osteoid had already been deposited. The patient was a boy of thirteen, whose roentgenogram showed a smallish, rarefied area in the spongiosa of a femoral condyle, surrounded by an area of osteosclerosis. He gave a typical history, and excision of the lesion resulted in prompt cure. Parts of the lesion are still so cellular that it could be mistaken for a somewhat atypical giant-cell tumor or an "osteoblastoma".



Cases of this type are usually misinterpreted as instances of sclerosing non-suppurative osteomyelitis or osteomyelitis chronic from the beginning. They are also sometimes held to represent sclerosing osteogenic sarcoma before the diagnosis is changed to one of the diagnoses just mentioned. Furthermore, before the era of serodiagnostic tests for syphilis such cases were not infrequently misinterpreted as instances of non-gummatous syphilitic osteoperiostitis.

CASE 8. The patient was a young woman, twenty-four years of age, who was treated at the Hospital on the Service of Dr. H. D. Sonnenschein. She was admitted because of a swelling near the base on the radial aspect of the fourth digit of the left hand. The swelling had been present for two years, but up to the past eight months had not been pronounced. Since then it had increased rapidly, and at the time of admission it was beginning to irritate the contiguous part of the middle finger. However, the enlarged area itself was not painful at any time. No special trauma had been noted in connection with the development of the condition.

The physical examination yielded no relevant findings, except the ones relating to the affected digit. The latter presented a marble-sized, firm swelling of the proximal phalanx on its medial aspect. It was firmly attached to the bone and was not tender to palpation except at its proximal end. On the basis of the clinical and roentgenographic findings, it was held that the lesion was an osteochondroma arising from the phalanx.

#### *Roentgenographic, Operative, and Pathological Findings*

The roentgenogram (Fig. 28) showed a rounded, bony protuberance, about one centimeter in diameter, connected with the cortex of the affected phalanx. This cortex, on the medial aspect, had evidently undergone some thickening. The surgeon exposed and removed the growth, which was found attached to the thickened cortex.

The specimen received in the laboratory consisted of a small semilunar osseous mass. Microscopically, it was found that the growth was covered on its convex surface by periosteum, beneath which was a thin shell of periosteally formed new bone (Fig. 29). The growth as a whole was composed of a substratum of osteogenic connective tissue, containing many irregular trabeculae of bone and osteoid. On the deep surface of the lesion, some osseous fragments were found, which apparently represented the original cortical bone of the phalanx.

*Summary:* This is a case of osteoid-osteoma in which the growth began under the periosteum and essentially remained there. Although the phalangeal cortex in the vicinity of its origin did become thickened, the growth itself did not become incorporated into and surrounded by this cortex. The absence of pain in this case would in itself have been a point against a diagnosis of osteoid-osteoma, since, in general, pain is a significant clinical feature of the condition in question. The freedom from pain in this instance seems to be attributable to the subperiosteal location of the growth, which permitted a sort of decompression of the latter.

#### TREATMENT

Surgery was the method of treatment used, and it gave prompt clinical cure. In some of our cases it consisted in removal of the osteoid-osteoma proper and some curettage of the perifocal bone. In others, especially when the osteoid-osteoma had developed in a shaft cortex, the growth was removed more or less intact in its bed of neighboring bone.

In fact, in some instances, the lesion was given a fairly wide berth, a rather large block of the adjacent bone being resected with it. While such wide resection is not altogether necessary, it has had the advantage of permitting satisfactory study of the pathology of the condition. Indeed, if, instead of block resection, only curettage is done, the osteoid-osteoma is likely to be destroyed for purposes of pathological study. It is true that the therapeutic end result would probably be the same with curettage. However, it is largely the customary use of curettage, with consequent destruction of the lesion in cases of osteoid-osteoma (misdiagnosed as some form of chronic osteomyelitis) that has delayed so long the histological identification of osteoid-osteoma.

Whether roentgenotherapy would cure the condition as surgery does, we cannot state. Up to the present, we have been grateful for the opportunity to study the excised specimens in order to become really familiar with the lesion. To one who thinks it advisable to have a biopsy specimen before undertaking roentgenotherapy, it can be pointed out that, since in cases of osteoid-osteoma the lesion is small, one usually may as well make the complete excision. However, at a future time, roentgenotherapy should be tried for some of these cases, especially if the lesion is in a site which is difficult to approach surgically, such as a vertebral body.

#### DISCUSSION AND LITERATURE

In accordance with the reasons given in the previous paper on osteoid-osteoma, we still interpret this lesion anatomically as a benign neoplasm of bone. On the other hand, the impression that the cases which we are classifying as instances of osteoid-osteoma have an infectious inflammatory basis is deeply ingrained in the minds of roentgenologists and surgeons. Nevertheless, it seems very clear to us that a great many cases which, in the past, have been interpreted specifically as "osteomyelitis with annular sequestrum", "chronic bone abscess", "osteomyelitis with cortical-bone abscess", "sclerosing non-suppurative osteomyelitis", "osteomyelitis chronic from the beginning", etc., actually belong in the category of osteoid-osteoma. That is, they have as their common anatomical basis a distinctive benign osteoid and bone-forming tumor, of slow and limited growth, which, in the course of its development, is likely to provoke reactive perifocal new-bone formation, sometimes of considerable extent. Much of the misunderstanding of the condition has resulted from concentration of attention upon this perifocal reaction instead of upon the lesion proper. In fact, unless the latter is removed (preferably intact in its bed of bone) and submitted for microscopic study, the true significance of the case may be missed, as it usually is.

#### *Evidence Against the Idea of an Inflammatory Basis for the Lesion*

Our experience with osteoid-osteoma covers thirty-three cases, varying as to the site affected, the duration of the clinical complaints, and

the stage of evolution of the lesion. If the idea of an infectious inflammatory basis had any validity, we should have found clear-cut evidence of inflammation in at least a few instances. Even microscopically, we did not find it in a single case, either in the lesion proper or in the perifocal tissue. Specifically, we failed to find microscopic evidence either of acute or of chronic pyogenic infection. The microscopic findings did not even support the assumption that a pyogenic inflammation had been present and had subsided, and that one was now looking at its residua. It should be noted that, at a site of previous pyogenic inflammation, some microscopic stigmata of the latter usually persist even after the condition is well on the way to clinical resolution. Since in all of our cases the lesion was still clinically active and, nevertheless, showed no signs of inflammation, it is clear that it could not be based upon pyogenic inflammation. Furthermore, this is borne out by the results of bacteriological examination. In every instance in which culture swabbings were taken from the osteoid-osteoma proper, the cultures have remained sterile, under both aerobic and anaerobic conditions.

And still, clinically and roentgenographically, the cases which we have discussed under the heading of osteoid-osteoma have for a long time been held to have an infectious inflammatory basis. Commonly they are interpreted as cases of sclerosing osteomyelitis, bone abscess, or a combination of the two. Instances of osteoid-osteoma developing in the shaft cortex of long bones have, in particular, been misinterpreted as cases of so-called sclerosing non-suppurative osteomyelitis of Garré. How and through whom these cases came to have this name attached to them we do not know. It is clear, however, that to apply it to them is not only incorrect in itself, but it indicates a misunderstanding of what Garré himself described under this heading.

On going back to Garré's original paper<sup>2</sup> of 1891, one notes first that the article as a whole is entitled: "*Einige seltene Erscheinungsformen der akuten infektiösen Osteomyelitis*" ("Some Unusual Expressions of Acute Infectious Osteomyelitis"). He discusses as one of a number of expressions of acute osteomyelitis "the sclerosing non-suppurative form". In this connection, he specifically states: "I wish to designate as sclerosing forms those infectious osteomyelitides which leave behind merely a distension and thickening of the bone, without leading to the development of suppuration and fistula formation. They set in in typical fashion quite acutely, at least in the majority of cases, and run their course with high fever, swelling of the extremity, painfulness and distension of the bones, and indeed even with considerable infiltration of the soft parts, which permits the expectation of prompt formation of abscesses. Instead, however, the infiltration regresses quite slowly, while the fever has already dropped and the patient is advancing slowly toward healing. Nothing remains but a more or less considerable distention of the bone."

In another paper<sup>3</sup> with a similar title, published in 1893, Garré repeats the essentials of this definition in connection with such cases. In a

paper by Peters <sup>11</sup> from Garrè's Clinic, published in 1919, Garrè's original definition is modified by the statement that sequestra and even fistulae develop in some cases of the so-called sclerosing non-suppurative form of acute infectious osteomyelitis.

That the cases to which Garrè referred under the aforementioned heading could by no stretch of the imagination be regarded as resembling those which are being described in the present paper should be clearly apparent. In our cases, neither the onset nor the course of the condition was associated with fever, the patients never presented sequestration of bone or fistulization, and there was no clinical indication whatever of infection. What Garrè was really describing were instances of acute osteomyelitis, as he himself stated. His own descriptions of these cases were written before the era of the roentgen ray in medicine. Furthermore, they preceded the general use of prompt incision and drainage in the treatment of pyogenic bone infections. Hence, the sequestra which must have formed were neither demonstrated roentgenographically nor exposed by operation upon the affected bone. It was only natural that he changed his mind about the "sclerosing non-suppurative form of osteomyelitis" when, in the course of years, the sequestra were expelled spontaneously through fistulization.

More plausibly, cases of osteoid-osteoma involving the shaft cortex of a long bone have been misinterpreted as instances of "osteomyelitis chronic from the beginning" ("*chronique d'emblée*"). For example, some of the cases discussed in Loiret's thesis <sup>8</sup> of 1924, "*Contribution à l'étude de l'ostéomyélite chronique d'emblée des os longs*", are undoubtedly of this type. Those discussed by Laffaille <sup>7</sup> under the title "*De l'ostéomyélite chronique d'emblée à forme pseudo-tumorale*" are probably also of this kind. Indeed, a search of the literature on osteomyelitis reveals, under these general headings or slight variants of them, a large number of papers (especially in French) describing cases which, to our minds, seem clearly to represent instances of osteoid-osteoma developing in long bones. In this group of cases, it is at least plain that there was no question, in the minds of the writers, of frank clinical pyogenic osteomyelitis. On the other hand, it is true that no anatomical description is given in these papers, which would enable one to establish unequivocally the presence of an osteoid-osteoma.

Furthermore, there are a few cases which, despite the presence of such revealing anatomical data, have, nevertheless, been misinterpreted as cases of osteomyelitis. One instance in point is the case described by Heine <sup>4</sup> in 1927 under the title "*Einheilender Knochensequester an der Grundphalanx des Ringfingers*" ("Bone Sequestrum in Process of Incorporation into the Basal Phalanx of the Ring Finger"). The patient was a farmer, twenty-six years of age, who had had complaints referable to the left index finger for over two years. A roentgenogram, taken some time before this finger was disarticulated, showed, in the distal metaphysis of the basal phalanx, a roundish, radiopaque shadow, which was

thought to represent a "sequestrum". Anatomically, too, the lesion represented by the shadow was regarded by Heine as a sequestrum.

However, the microscopic findings which Heine himself records do not support this interpretation. In the first place, he makes no mention of any dead bone or evidence of inflammation in the lesion in question. Furthermore, he states that it is composed substantially of osteoid, which is undergoing spotty calcification and which has developed out of a vascular spindle-cell connective tissue. To accept this as a sequestrum—even an organizing one—is to discard all the generally accepted criteria of what a sequestrum is. Certainly no unequivocal sequestrum that we have seen has contained anything like this structure within or near it. It seems clear to us, on the basis of Heine's own detailed description, that what he was calling an organizing sequestrum was actually an osteoid-osteoma.

Phemister<sup>12</sup>, too, has reported, under the general heading of osteomyelitis, several cases which seem to us to represent clear-cut instances of osteoid-osteoma. At least one of the cases recorded in his article of 1929, entitled "Chronic Fibrous Osteomyelitis", is of this type. Again, in his chapter on pyogenic osteomyelitis in the monograph "Orthopedic Surgery", edited by Ghormley in 1938, Phemister<sup>13</sup> reports some cases which are of this kind. They are discussed under the heading of "localized osteomyelitis with a chronic onset". Specifically, he conceives the cases in question as representing the healing stages of acute but localized and low-grade or attenuated pyogenic bone infections. This idea is based upon the hypothesis that "were it possible to observe the pathology at the onset, there probably would be some evidences of acute pyogenic infection, but of mild degree and without extensive necrosis of bone".

Phemister adheres to his conception, despite the fact that he had been unable to grow bacteria out of any of his lesions, that microscopically there was no evidence of inflammation in them, and that the lesion sometimes reminded him of giant-cell tumor or of the organizing stage of osteitis fibrosa. We cannot go along with him when he thus postulates for certain cases an infection basis which is left hypothetical by his own anatomical and bacteriological findings. On close analysis, even the clinical findings in these cases fail to support this hypothesis, although superficially they may seem to do so when the lesion is in the shaft cortex of a long bone.

Another kind of evidence, too, can be offered against the idea of an infectious inflammatory basis for the lesion being designated as osteoid-osteoma. This evidence is our failure to find, in an extensive experience with tissue from unequivocal cases of pyogenic osteomyelitis, anything like this lesion in connection with it. Indeed, we have studied material from cases of osteomyelitis, varying widely as to location, duration, and severity, without ever noting microscopically an area presenting the composite histological picture of osteoid-osteoma. We have likewise been unable to find this picture in the few anatomically proved cases of solitary bone abscess which we have seen. In them, the abscess cavity remains

lined by a pyogenic membrane and filled with pus, either frank or modified. In the course of time, a solitary abscess cavity may diminish in size, but we have never found it being filled by osteogenic connective tissue, containing calcifying osteoid and bone, such as constitutes the essential tissue of an osteoid-osteoma.

*Evidence Against the Idea That the Lesion Represents a Peculiar Healing or Reparative Form of Some Familiar Condition*

It would not be surprising if this idea were suggested as an alternative to that of inflammation. It might be argued, for instance, that the lesion represents a peculiar healing reaction to a trauma. However, in more than half of our cases the patients gave no history of trauma relevant to their complaints. Assuming that there had been a relevant acute trauma, the principal possibilities to be considered would seem to be fracture, hemorrhage without fracture, or aseptic necrosis.

As to the possibility that we are dealing with the repair of a post-traumatic necrosis, there is nothing in the pathology of our cases to suggest this. Indeed, there is no vestige of aseptic necrosis, either in the osteoid-osteoma proper or in the perifocal osseous tissue. The idea of development of the lesion at a site of hemorrhage without fracture is also unacceptable. Notably, it is difficult to conceive, in relation to long bones, a hemorrhage sharply restricted to a small area within the cortex itself or in its periosteal or medullary surface. Even the occurrence of a sharply localized hemorrhage in the spongiosa is difficult to conceive. Furthermore, even granting the possibility of such a hemorrhage, one still finds it difficult to explain the osteoid-osteoma as the expression of its atypical organization and repair. Certainly, if this were the correct interpretation, we should have found somewhere in the numerous slides prepared from the specimens in our thirty-three cases some unequivocal indications of organization and repair following hemorrhage. As to the possibility that osteoid-osteoma represents a peculiar healing reaction to an infraction or small fracture, it is only necessary to note that, if this were the case, we should have found cartilage in some specimens as an expression of callus formation.

The possibility that the lesion might represent a peculiar healing form of giant-cell tumor, "localized osteitis fibrosa", or cyst also requires mention. In regard to giant-cell tumor, it is well known that this has a predilection for epiphyses of long bones. On the other hand, in all but a few of the many instances in which osteoid-osteoma appeared in these bones, it developed in the shaft cortex at some distance from an epiphysis. It might be thought that this abnormal site of origin could in itself account for the failure of the hypothetical giant-cell tumor to attain large size. Against this point there is the fact that when an osteoid-osteoma does develop in an epiphysis it still remains a smallish lesion. Finally, the cytological pattern of osteoid-osteoma is not to be found in typical giant-cell tumor. Altogether, then, there is no reason for regarding an

osteoid-osteoma as a giant-cell tumor, even one that is abortive or undergoing abnormal healing.

To classify osteoid-osteoma under the heading of "localized osteitis fibrosa" might be tempting, but is not illuminating. Indeed, "localized osteitis fibrosa" is a "waste-basket" term in bone pathology, holding many ill-assorted concepts. For instance, solitary bone cyst is still sometimes regarded as one expression of "localized osteitis fibrosa", of which another is supposed to be giant-cell tumor. Furthermore, the literature contains many reports on cases of solitary fibroma and fibrous dysplasia of bone also discussed under the heading of "localized osteitis fibrosa". One may then very well ask: "What is localized osteitis fibrosa?" We know of no sensible answer to this question. Therefore, to classify osteoid-osteoma as a "localized osteitis fibrosa" only throws one more entity into the waste basket. Finally, the idea that an osteoid-osteoma might represent the healing stage of a bone cyst is obviously far-fetched.

#### *Evidence Against the Idea That the Lesion Originates from an Embryonic Rest*

The supposition that an osteoid-osteoma might represent an embryonic rest, either static or growing, can likewise be controverted. In the first place, it is known that simple rests in bone do not give rise to clinical symptoms. Furthermore, the most common rests are cartilaginous ones, and no trace of cartilage is to be found in an osteoid-osteoma. It is true that cartilaginous rests not infrequently undergo transformation into bone, resulting in enostoses, but this transformation is not associated with any clinical symptoms. Indeed, solitary or even multiple enostoses (the so-called "bone flecks") are encountered only accidentally by the roentgenologist or by the pathologist. They are most likely to be found in the spongiosa of long bones. They consist of nests of compacted trabeculae of adult lamellar bone, distinguished from the neighboring normal trabeculae only by this denser consistency. Thus, being in spongiosa, a solitary bone fleck bears a superficial roentgenographic resemblance to a highly ossified osteoid-osteoma in such a location. However, even in such a site, an osteoid-osteoma ought not to be confused with a solitary bone fleck. In our experience, an osteoid-osteoma, even when present as a radio-paque nidus in spongiosa, still gives rise to clinical complaints. Furthermore, as must be clear from our discussion of the microscopic appearances, it differs also histologically from a solitary enostosis (Figs. 4, 5, and 6).

#### *Reasons for Interpreting Osteoid-Osteoma as a Benign Tumor of Bone*

From the clinical and pathological findings and the individual case reports, it seems justifiable to deduce that osteoid-osteoma represents a lesion *sui generis*.\* In all our cases, we were able to demonstrate within

\* We shall cite here the opinion of Dr. James Ewing as to the nature of the lesion. After we had submitted our manuscript for publication we showed him our material, requesting his comments. We did this because of the tenacity of the old belief, on clinical and roentgenographic grounds, that cases such as we are discussing under the head of osteoid-osteoma have an infectious inflammatory basis, and because of the fact that our own opinion contrasts so strongly with this long-accepted belief.

the affected bone area a small, sharply delimited focus composed of varying proportions of osteoid and more or less calcified atypical new bone, and developing, as cases representing different stages revealed, out of a cellular osteogenic connective tissue. In its evolution, the lesion follows a consistent pattern: It passes from (1) an initial stage, in which actively proliferating and compacted osteoblasts may be prominent (Fig. 30), through (2) an intermediate phase, in which osteoid in various stages of calcification is conspicuous (Figs. 6 and 22), to (3) the mature stage, in which the lesion resembles an osteoma composed of densified trabeculae of highly calcified atypical bone (Figs. 26 and 27). The fully evolved osteoma is so distinctive in its microscopic appearance that one can recognize it at a glance.

Moreover, osteoid-osteoma develops without apparent cause and cannot plausibly be ascribed to infection, however low-grade, to traumatic injury, or to any other demonstrable factor, for reasons indicated in the preceding discussion. The focus of atypical new bone thus developing apparently constitutes an autonomous lesion displacing the bone that would normally occupy the region and pursuing its full course of evolution unless interrupted by surgical intervention. To be sure, the presence of the slowly expanding focus is usually associated with pronounced sclerosis of the neighboring osseous tissue, and indeed, when it develops in a shaft cortex, the lesion may become incased in the thickened and sclerotic cortical bone. However, the sclerotic perifocal osseous tissue in no way resembles the lesion proper, which always maintains its identity.

Taking all these factors into consideration, it seems to us that osteoid-osteoma satisfies the criteria generally laid down by oncologists for a tumor or new growth. The small size of the mature lesion (up to two centimeters in diameter) and its seemingly self-limited nature do not necessarily controvert this conception, since it is well known that other benign tumors of connective-tissue origin may be quite small with limited growth. In the direction of excluding the possibility of malignant transformation of osteoid-osteoma, it can be said that, during our experience with the lesion (now covering seven years), no recurrence has been noted in any of our cases. Indeed, in 1936, in a presentation of the subject before the American Association of Pathologists and Bacteriologists,<sup>6</sup> it was suggested that osteoid-osteoma is possibly the benign counterpart of osteogenic sarcoma. However, this suggestion is merely an idea worth considering, and not a definite stand. In this connection, it can be stated that

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In his letter, dated April 12, 1940, Dr. Ewing states: "I find it somewhat difficult to interpret the process which you designate as osteoid-osteoma. The lesion is specific and peculiar. There are several features which favor the interpretation as a neoplasm. The process is circumscribed and independent of the surrounding tissue hypertrophy. It has its own blood supply in the form of numerous dilated venous sinuses. The new growth of osteoid tissue is excessive and somewhat atypical. The cells from which the new bone is developed are hyperchromatic and atypical, and they are overnumerous. There are no definite traces of any strictly inflammatory process, no old blood pigment, no leukocytes, no remnants of old pus, and no old necrotic debris. On the basis of these features one is justified in regarding the process as a form of neoplasm. I cannot understand how such a process can result from infectious osteomyelitis."



tissue areas showing an osteoid-and-bone pattern like that which one sees in osteoid-osteoma are found otherwise only in sclerosing osteogenic sarcoma.

We now turn briefly to a few relevant articles which have appeared since our previous paper on osteoid-osteoma. Three of these are reactions to our concept of the lesion as developed in that paper. The fourth deals with a similar but not closely analogous lesion occurring in the nasal accessory sinuses.

Marziani <sup>9</sup>, in 1936, published a paper entitled "*Sul cosiddetto osteoma osteoide*" ("The So-Called Osteoid-Osteoma"). He reported the case of a girl of fourteen, who showed, in the spinous process of the fourth lumbar vertebra, a lesion which he regarded as corresponding to the one which we had described. He, too, felt that the lesion belonged to a distinctive category, and he tended toward the opinion that it was a neoplasm, although he did not yet wish to be emphatic on that point. In 1938, under the title of "*Osservazioni cliniche ed anatomo-istologiche sull' infiammazione primitiva cronica della spongiosa ossea*" ("Primary Chronic Inflammation of Spongy Bone"), Mondolfo <sup>10</sup> published a paper dealing with the lesion in question, but, as his title implies, he rejected the conception of it as a neoplasm. Mondolfo's paper includes seven cases, three of which he discusses in detail to bring out their complete similarity to the ones originally described by Jaffe. He interprets the lesion as representing a direct or primary reparative inflammatory reaction of the spongiosa to an attenuated infection. He takes the lack of microscopic signs of inflammation in connection with the lesion as evidence of attenuation of the infection. At best, his conception is only a hypothesis, opposed notably by the fact that, in connection with the healing of known infections of bone of long standing, tissue corresponding to what we have called osteoid-osteoma does not appear. Mondolfo's insistence that osteoid-osteoma represents an inflammatory lesion stands in contrast to the acceptance by Thoma <sup>14</sup>, in 1938, of the lesion as a tumor. The latter author pictures, in relation to the mandible, a rather closely analogous lesion which he calls a fibro-osteoma.

Finally, Benjamins <sup>1</sup>, in 1938, under the title, "*Das Osteoid-Fibrom mit atypischer Verkalkung im Sinus frontalis*" ("Osteoid-Fibroma with Atypical Calcification in the Frontal Sinus"), discusses a less closely analogous lesion, which developed in the left frontal sinus. His patient was a girl of nineteen in whose case the history dated back seven years and in whom he found a tumor of rather gritty, crumbly consistency occupying the sinus and apparently originating from the periosteum of the orbital roof. The lesion was composed basically of osteoblastogenic connective tissue, containing also miliary osteoid concretions, which had undergone atypical calcification. This osteoid-fibroma differed from the lesion which we have described as osteoid-osteoma in that, despite its age, it contained no genuine bone, while an osteoid-osteoma eventually shows this. Nevertheless, Benjamins regarded the lesion in his case as a special type of benign tumor, and indeed the pathologist who had first examined it thought it represented a malignant tumor, specifically an

osteosarcoma. Benjamins recorded from the literature five other cases showing lesions of this type in nasal accessory sinuses, and classified them under the single heading of osteoid-fibroma with atypical calcification.

#### SUMMARY

On the basis of additional experience, the condition which one of us (H. L. J.) described in 1935 under the name of *osteoid-osteoma* has again been considered. Including the five cases originally described, our total experience with the condition now covers thirty-three cases. In the present paper, we have, of course, drawn on this total experience for the statistics and the general sections on the clinical, roentgenographic, pathological, and therapeutic findings. In addition, this paper records details on eight cases (not including any already described in the original paper) which have been selected to convey a well-rounded picture of the condition as one encounters it in individual instances.

Our thesis is that osteoid-osteoma constitutes a lesion *sui generis* and specifically is a distinctive benign tumor appearing in bones. It is always a small lesion affecting a single bone. It may develop in the spongiosa or in the cortex of the affected bone, and it stands out from the surrounding osseous tissue as a sharply delimited nidus. The latter is usually composed of osteoid and more or less calcified atypical new bone, which can be seen to have developed out of a rather vascular osteogenic connective tissue. From the findings in our series of cases, an osteoid-osteoma seems to run the following histogenetic course: It appears to pass from (1) an initial stage, in which actively proliferating and compacted osteoblasts may be prominent, through (2) an intermediate phase, in which osteoid in various stages of calcification is conspicuous, to (3) the mature stage, in which the prominent feature of the lesion is the presence of densified trabeculae of highly calcified atypical bone. When an osteoid-osteoma develops in spongiosa, a narrow or even fairly wide zone of the surrounding spongy osseous tissue usually becomes densified and sclerotic; if an osteoid-osteoma develops in cortex, the latter, too, tends to become thickened, mainly through periosteal new-bone deposition. In fact, if the lesion develops in the cortex of a long bone, as it not infrequently does, the reactive cortical thickening may be very striking.

Thus, in interpreting the roentgenographic picture in a case of osteoid-osteoma, one must remember that this picture has two aspects,—the manifestation of the osteoid-osteoma proper and that of the reaction which it has incited in the surrounding tissue. The osteoid-osteoma proper is usually indicated roentgenographically by a relatively radiolucent or rarefied area, although, if it has become substantially ossified, it may appear as a relatively radiopaque nidus. In the cortex of a long bone, one may have difficulty in distinguishing the osteoid-osteoma shadow if the reactive cortical thickening is considerable or if the lesion has become ossified, since its shadow may be dominated by that of the thickened cortex. In any event, because the roentgenographic picture has these two aspects, a case of osteoid-osteoma in a spongy-bone area is

tissue areas showing an osteoid-and-bone pattern like that which one sees in osteoid-osteoma are found otherwise only in sclerosing osteogenic sarcoma.

We now turn briefly to a few relevant articles which have appeared since our previous paper on osteoid-osteoma. Three of these are reactions to our concept of the lesion as developed in that paper. The fourth deals with a similar but not closely analogous lesion occurring in the nasal accessory sinuses.

Marziani <sup>9</sup>, in 1936, published a paper entitled "*Sul cosiddetto osteoma osteoide*" ("The So-Called Osteoid-Osteoma"). He reported the case of a girl of fourteen, who showed, in the spinous process of the fourth lumbar vertebra, a lesion which he regarded as corresponding to the one which we had described. He, too, felt that the lesion belonged to a distinctive category, and he tended toward the opinion that it was a neoplasm, although he did not yet wish to be emphatic on that point. In 1938, under the title of "*Osservazioni cliniche ed anatomo-istologiche sull' infiammazione primitiva cronica della spongiosa ossea*" ("Primary Chronic Inflammation of Spongy Bone"), Mondolfo <sup>10</sup> published a paper dealing with the lesion in question, but, as his title implies, he rejected the conception of it as a neoplasm. Mondolfo's paper includes seven cases, three of which he discusses in detail to bring out their complete similarity to the ones originally described by Jaffe. He interprets the lesion as representing a direct or primary reparative inflammatory reaction of the spongiosa to an attenuated infection. He takes the lack of microscopic signs of inflammation in connection with the lesion as evidence of attenuation of the infection. At best, his conception is only a hypothesis, opposed notably by the fact that, in connection with the healing of known infections of bone of long standing, tissue corresponding to what we have called osteoid-osteoma does not appear. Mondolfo's insistence that osteoid-osteoma represents an inflammatory lesion stands in contrast to the acceptance by Thoma <sup>14</sup>, in 1938, of the lesion as a tumor. The latter author pictures, in relation to the mandible, a rather closely analogous lesion which he calls a fibro-osteoma.

Finally, Benjamins <sup>1</sup>, in 1938, under the title, "*Das Osteoid-Fibrom mit atypischer Verkalkung im Sinus frontalis*" ("Osteoid-Fibroma with Atypical Calcification in the Frontal Sinus"), discusses a less closely analogous lesion, which developed in the left frontal sinus. His patient was a girl of nineteen in whose case the history dated back seven years and in whom he found a tumor of rather gritty, crumbly consistency occupying the sinus and apparently originating from the periosteum of the orbital roof. The lesion was composed basically of osteoblastogenic connective tissue, containing also miliary osteoid concretions, which had undergone atypical calcification. This osteoid-fibroma differed from the lesion which we have described as osteoid-osteoma in that, despite its age, it contained no genuine bone, while an osteoid-osteoma eventually shows this. Nevertheless, Benjamins regarded the lesion in his case as a special type of benign tumor, and indeed the pathologist who had first examined it thought it represented a malignant tumor, specifically an

## A SPECIAL STUD-BOLT SCREW FOR FIXATION OF FRACTURES OF THE NECK OF THE FEMUR

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In this paper the author wishes to describe a device and technique for osteosynthesis of the neck of the femur, which he has used successfully in ten cases. The technique is very simple, and only a few instruments are necessary. In each case the operation has been performed more easily and speedily than any other previously used method, and the result has been excellent.

A good osteosynthesis of the neck of the femur demands: (1) that the operation be associated with a minimum of shock and of local trauma; (2) that the mechanical principles utilized be sound; and (3) that the fixation be solid and durable.

The Smith-Petersen nail is most frequently used at present. Its introduction was indeed a turning point in the treatment of this type of fracture, yet it presents certain technical limitations:

1. The impaction obtained by the nail lacks firmness, and very often the nail slips out.

2. The use of a mallet to introduce the nail induces trauma, which is responsible in a measure for the trophic disturbances that are often encountered.

3. On account of the absence of complete fixation and impaction, the newly formed blood vessels, emerging from the trochanteric aspect to the head of the femur, are torn. Because of this, the nutrition of the head is further impaired, causing an exaggeration of the trophic disturbances.

4. A second operation may occasionally be necessary, in order to remove a nail which has slipped, but which otherwise has been well tolerated.

Because of these limitations, the author began a search for a method of fixation which would promise greater stability. It was evident from the first that a screw has better fixation qualities than a nail. A large number of screws have been designed for the neck of the femur. Henderson, Lippmann, Putti, and others have adopted stud-bolt screws. The so-called stud-bolt type of screw has been used for a long time by Lambotte and others in the treatment of fractures of the long bones. The French authors call it "*boulon*". After many experiments on dry bones, the author designed a special-thread stud-bolt screw (Fig. 1) with its center cannulated to permit the passage of a Kirschner wire. It consists of three parts: (1) the screw itself; (2) a cupped flange; and (3) the locking

nut. The flange is hollow and is made with an inclination to suit the bone surface. The nut is inserted inside the flange. The tightening adjustment takes place at the inner end of the nut within the flange. The nut is hollow at its inner end and is threaded to receive the distal portion of the screw. The thread of this screw is similar to the helicoid screw of Danis, but it is much higher and sharper. *The thread takes hold only in the head of the femur.*



FIG. 1

The screw is a special-thread stud-bolt device with its center cannulated to permit the passage of the wire. (Courtesy of Brasil-Medico.)

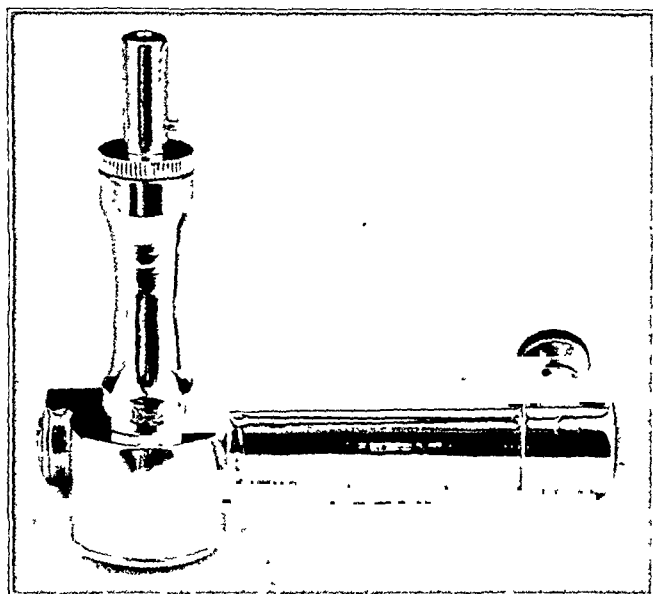


FIG. 2

Special attachment (elbow) for mounting the drill and burr to the motor. The direction of motion is changed by means of a right-angled gear.

of the motion. A portion of this instrument which is attached to the drill is perforated at its base for the insertion of the Kirschner wire.

A new set of instruments was also devised to facilitate the correct insertion of the screw. This set consists of two cannulated electric drills, a wrench, and a special "elbow" attachment (Fig. 2) for mounting the drill and burr at a right angle to the motor. The drill is connected with the elbow which is provided with a revolving spindle, the two parts of which are joined at its center by a right-angled gear to change the direction

#### REPORT ON THE FLEXION STRESS OF THE SCREW

The Institute of Technicological Research of the State of São Paulo was asked to test the strength of the fragments of a fractured human femur, held together by the author's stud-bolt screw, when pressure was applied at both ends. The Amsler apparatus, designed for a maximum load of 500 kilograms, was employed. Under a load of 100 kilograms, slight motion to the extent of five-tenths of a millimeter was observed by



FIG. 3

Fragments of fractured human femur, held together by stud-bolt screw, being tested on Amsler apparatus.

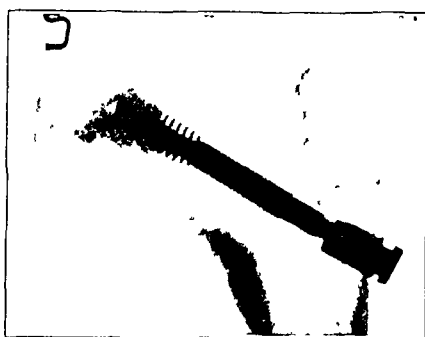


FIG. 4

Specimen shown in Fig. 3. Impaction of fragments was secure until 150 kilograms of pressure was applied.

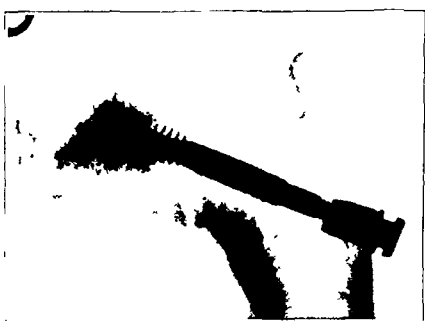


FIG. 5

Same specimen as in Figs. 3 and 4. At 251 kilograms of pressure the screw had begun to bend.

means of a microscope. When a load of 150 kilograms was applied, the sliding motion increased and was visible to the naked eye. Under 251 kilograms of pressure, the screw began to bend, and it broke under a stress of 317 kilograms. Further experiments established the fact that fractured bones held together by these special screws were stronger than unfractured bones.

It should be added that the conditions of the experiments were far less favorable than actually exist in living bone, because living bone is never subjected to a continuous strain as in this test, and, with its added elasticity, it would be more resistant to pressure. Furthermore, an oblique fracture was tested, and in this type the fragments have the greatest tendency to slide and to separate.

The Institute was also consulted to determine whether the screw was weakened by the cannulation and reported that the screw is almost as resistant to bending forces as a non-cannulated screw of the same size.

#### OPERATIVE TECHNIQUE

After the fracture has been reduced, both limbs are maintained at a 45-degree angle of abduction and the fractured limb in 25 degrees of internal rotation. Under local anaesthesia, an incision, about six cen-

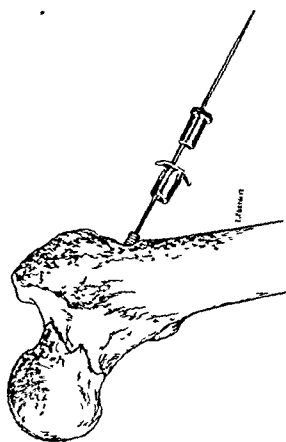


Fig. 9

With the screw in place, the cupped flange is introduced and adapted to the first portion of the tunnel; the locking nut is placed in the opening of the flange (Courtesy of Brasil-Medico.)

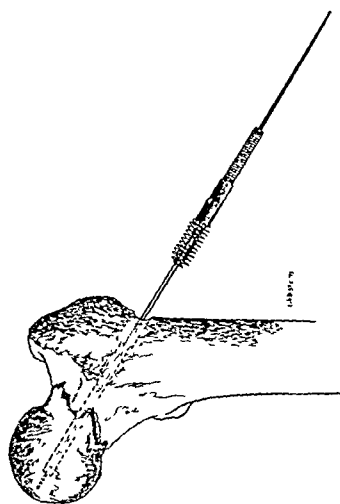


Fig. 7

Showing the screw being guided over the wire. (Courtesy of Brasil-Medico.)

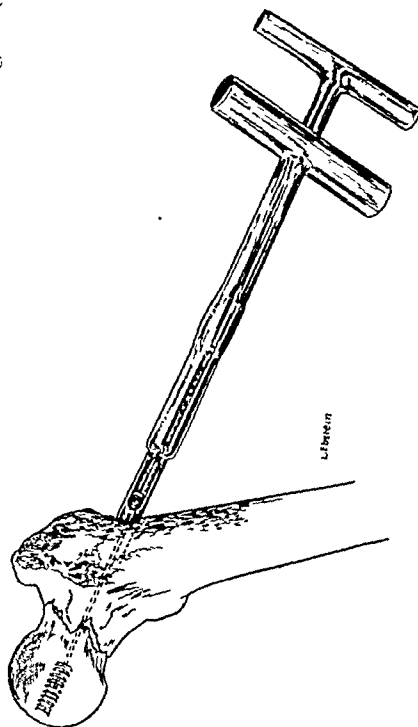


Fig. 8

Fixation of the screw with the special wrench. (Courtesy of Brasil-Medico.)

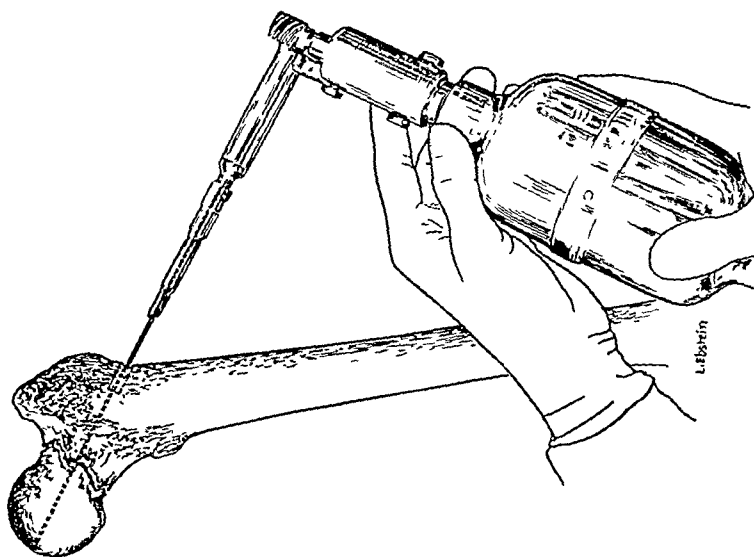


Fig. 6

Preparation of the channel for the introduction of the screw. (Courtesy of Brasil-Medico.)

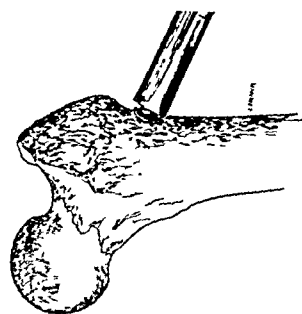


Fig. 10

With an open-end socket wrench, the nut is taken up on the screw until it is tight. (Courtesy of Brasil-Medico.)

timeters long, is made on the outer aspect of the greater trochanter. Two centimeters below the tuberosity of the femur and slightly anterior to the middle of the outer aspect of the shaft, a Kirschner wire, two millimeters thick and thirty centimeters long, is introduced through the greater trochanter and into the center of the neck of the femur, using one of the well-known guards. In four of the author's cases the wire was introduced through the skin under local anaesthesia without exposure of the bone. The incision was made only after the wire had been correctly inserted. Thus the actual time required for the open operation is only a few minutes. It is important that the wire be placed in the center of the neck. If the first attempt fails, the wire may be withdrawn and reinserted, or the original wire may be left *in situ* as a guide for the second. The position of the wire is always subject to roentgenographic confirmation. The rotary movement by means of which the wire is introduced causes it to fit rather loosely. A few taps of a mallet drives it in a little farther and makes it fit more snugly.

The next step provides for a channel for the screw. This channel is made with an electric burr of the author's design (Fig. 6), which is grooved for the purpose of fitting over the wire. The burr perforates the bone to a depth of two centimeters, which is

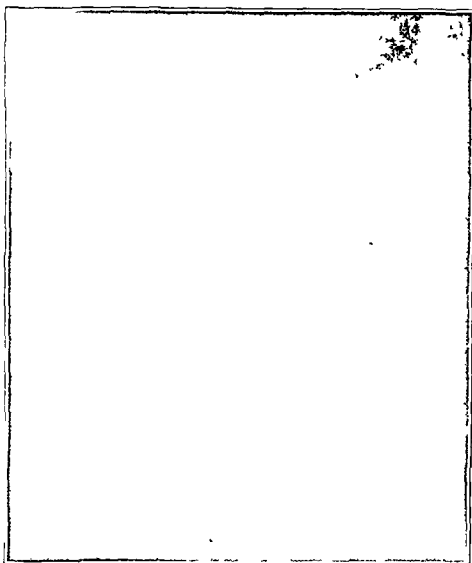


FIG. 11-A

Case 1. J. de C., male, aged forty-two years. Roentgenogram on August 29, 1938, showing fracture of neck of right femur.

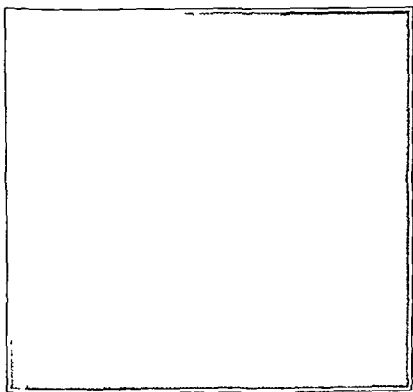


FIG. 11-B

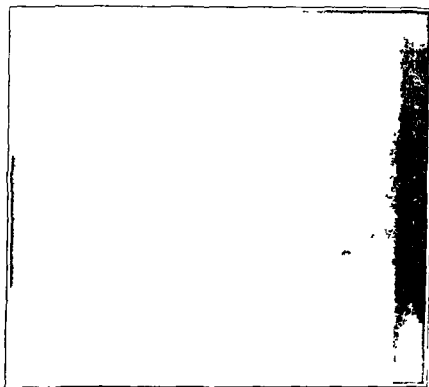


FIG. 11-C

Case 1. Anteroposterior and lateral roentgenograms, showing accurate reduction of fracture.



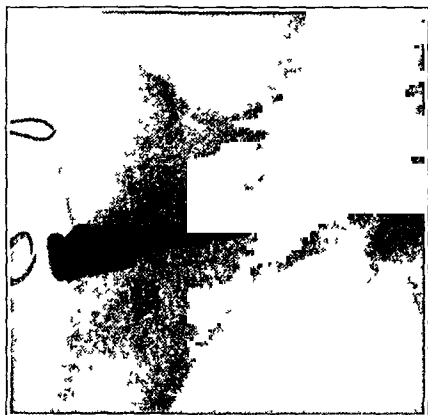


FIG. 11-D

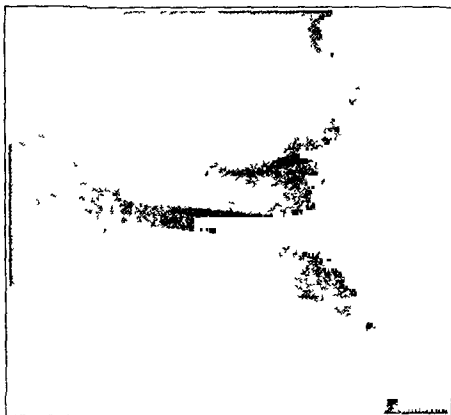


FIG. 11-E

FIG. 11-D

Case 1. The screw in place. Note the impaction obtained and also that the screw is of the proper size and length.

FIG. 11-E

Case 1. Lateral view of screw in place.

FIGS. 11-F, 11-G, and 11-H

Case 1. Photographs showing function of the limb eighty-five days after operation.

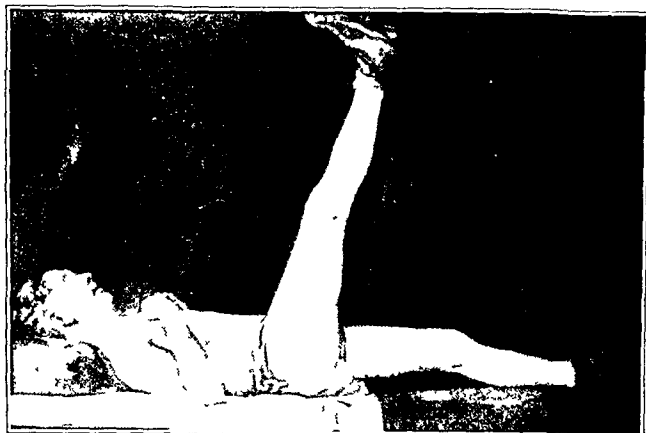


FIG. 11-F



FIG. 11-G

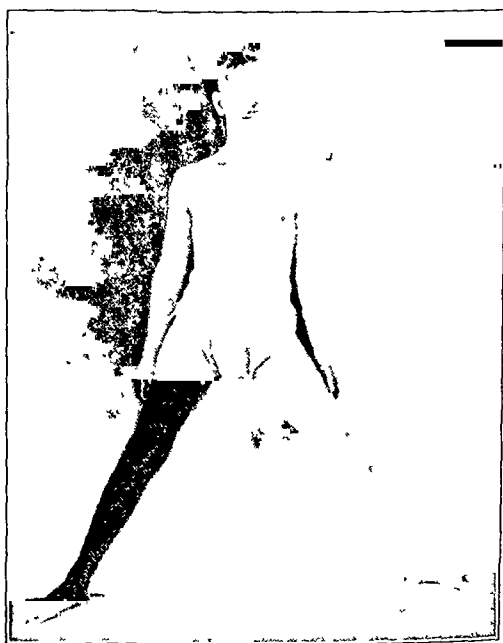


FIG. 11-H



FIG. 11-I



FIG. 11-J

Case 1. Roentgenograms showing result on December 29, 1939.

sufficient to receive the cupped flange. The channel is then extended with another drill, which is longer and narrower than the first (burr) and which is designed to permit the introduction of the screw. The depth of this perforation is determined from the roentgenograms and is limited by means of a regulating device. The channel must not be made so deep as to loosen the wire completely. In spite of this precaution, if the wire should slip out as the drill is being withdrawn, it is very easy to replace it. The drill is reintroduced into the bone channel; then the wire guided by the drill is driven in and fixed in the head of the femur with a few taps of the mallet, just as before.

With a special type of wrench (Fig. 8), the screw is then introduced. When the screw is in place, the flange is introduced and adapted to the first portion of the channel. The locking nut is next placed in the opening of the flange and is manipulated until the threads catch the screw. *The locking nut has been so constructed that, even if the screw is short and does not protrude, it can be caught and threaded in the interior of the flange. This has the advantage of permitting the use of a somewhat shorter screw than is otherwise employed, thus avoiding the necessity of cutting off the protruding extremity.* With an open-end socket wrench, the nut is then taken up on the screw until it is tight,—that is, until the head of the femur has been brought into firm contact with the distal fragment.



FIG. 12-A

Case 3. A.A., female, aged sixty years. Roentgenogram on September 7, 1938, thirty-nine days after fracture of left femur, showing absence of reduction.

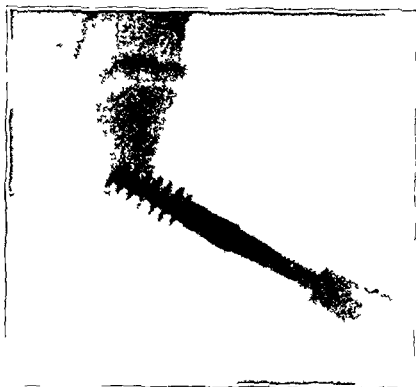


FIG. 12-B

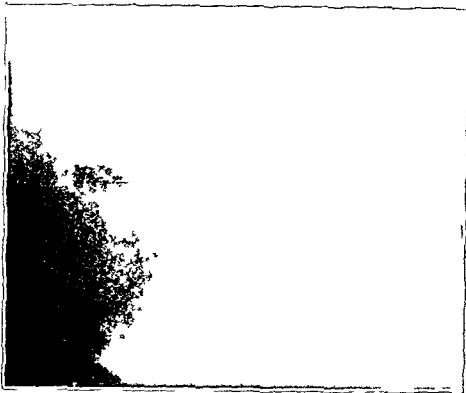


FIG. 12-C

Case 3. Anteroposterior and lateral roentgenograms, on September 19, 1938, the day after operation.



FIG. 12-D



FIG. 12-E

Case 3 Showing function seventy-five days after operation.

The bone fragments adapt themselves to each other in such a way as to form a solid unit, since the pressure of the impaction obtained by the screw may be carried to any desired degree. *This pressure can be developed to a point only possible by the use of such a high helicoid thread, which takes a very firm hold in the head of the femur.*

#### ROENTGENOGRAPHIC TECHNIQUE

It is preferable to use two portable roentgen-ray machines,—one for the anteroposterior view and the other for the lateral view. The advantages of two machines are self-evident: much time is saved, and there is less danger of interference with asepsis by reason of frequent manipulation of the tube.

Normally only seven roentgenograms are required. The first measures the length of the neck of the femur, in order to determine the proper length of the screw. The second, taken in both planes, checks the reduction of the fracture. Two more roentgenograms are taken to check the position of the wire, and the final films at the end of the operation confirm the proper placing of the screw.

## DISCUSSION

The following discussion shows that the method described meets the requirements of a good osteosynthesis of the neck of the femur:

1. The simplicity of this technique is apparent. The trauma is minimal, and the only hammering required is a few taps of the mallet on the tip of the wire. Very little cancellous bone is destroyed.

2. The mechanics are so precise and so simple that no extraordinary skill is required. The preparation of the channel for the screw in the neck of the femur by means of an *electrically operated drill*, guided by the wire, avoids the possibility of an error, and there is *no danger that the head will turn or become dislocated*, as during the use of a hand drill. It is obvious that once the channel is prepared the screw can be introduced exactly into the center of the neck with complete security.

3. The third requisite, *solidity*, is perfectly fulfilled by this technique. Particular care has been taken in the selection of the steel used to make the screw, and the resistance, solidity, and fixation have been carefully tested.

The metal used in the manufacture of the screw is known technically as "austenitic" stainless steel and contains 18 per cent. chromium, 8 per cent. nickel, and a small amount of molybdenum. This steel was finally selected after experiments with six



FIG. 12-F

Case 3. Showing function seventy-five days after operation.



FIG. 12-G

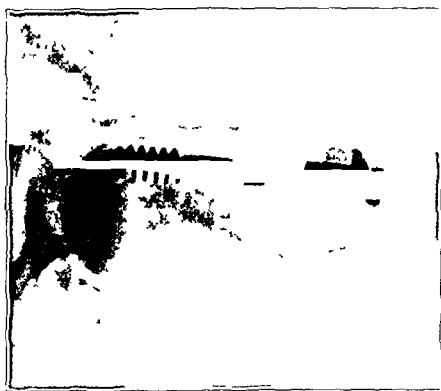


FIG. 12-H

Case 3. Anteroposterior and lateral roentgenograms, showing result on June 14, 1939.

different types of stainless steel. At present, the screw is also made of vitallium.

#### CLINICAL APPLICATION

This operation has been performed in ten cases. Two of them are too recent to estimate the results, but, of the remaining eight cases, a postoperative period of from ten to sixteen months has elapsed in seven. One patient (Case 2) was walking very well, but died eight months after the operation from a cerebral hemorrhage. The other seven patients are in perfect condition. They can walk freely without pain, and they have bony union with a full range of motion. The roentgenograms which are reproduced are the most recent that could be obtained, and they show the anatomical conditions. Where recent roentgenograms could not be obtained, the author has given the information which he has received in regard to the actual condition of the patients.

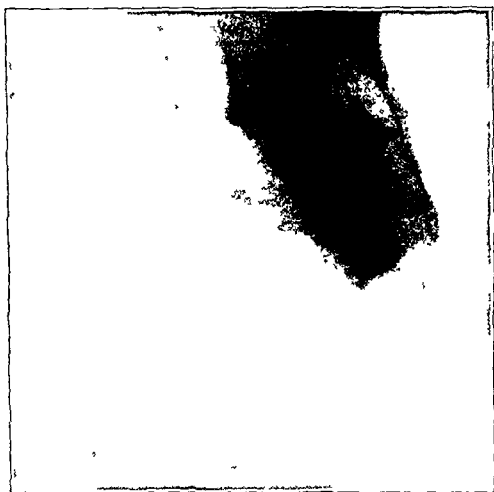


FIG. 13-A

Case 4. J. M., male, aged forty-five years. Roentgenogram twenty days after fracture of neck of right femur, showing absence of reduction.



FIG. 13-B



FIG. 13-C

Case 4. Anteroposterior and lateral roentgenograms, showing screws correctly placed.

on the ninth postoperative day. On that day the patient was able to walk, but, as a matter of precaution, he was ordered to keep off his feet for three months. He was discharged from the hospital, and, as he felt no pain, he bore weight on the limb and walked freely. In January 1910 this patient was walking without restriction and without pain or fatigue. He had bony union and a normal range of motion.

CASE 2. A. C. C., male, sixty years of age, fell and fractured the neck of the right femur. Six weeks afterward, on September 4, 1938, he was admitted to the hospital with the fracture still unreduced. Traction in abduction and flexion was applied, and an operation was performed on September 9, 1938. *No plaster cast was applied*, and healing took place *per primam*. The patient sat up the day after the operation and walked on the twentieth day. He was walking very well and without pain, but he suffered a cerebral hemorrhage eight months after the operation and died a few weeks later.

CASE 3. A. A., female, sixty years of age, was admitted to the hospital on September 15, 1938. She had fallen and had fractured the neck of the left femur forty-five days previously. Traction in the usual position was applied for three days. An operation, by the technique described, was performed on September 18, 1938. *No plaster cast was applied*. The patient sat up the following day, and the wound had healed *per primam* on the eighth day. Walking was possible on the fourteenth day. In January



FIG. 13-D



FIG. 13-E

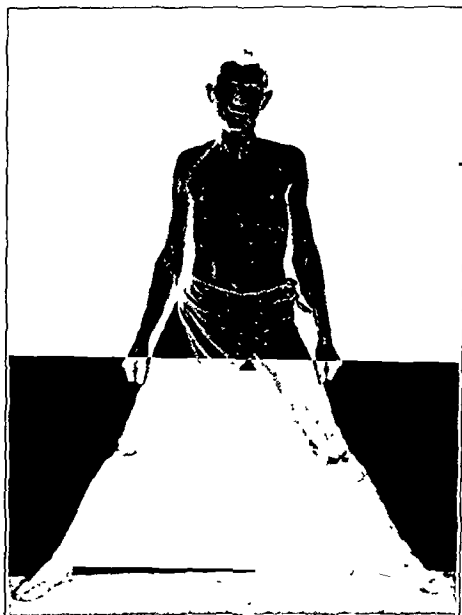


FIG. 13-F

Case 4. Photographs showing function fifty-eight days after operation.



FIG. 13-G

Case 4. Roentgenogram on December 1, 1938, fifty-eight days after operation.

sit up and move the leg freely. Healing took place *per primam*, and the patient walked on the tenth day. Since then she has walked normally and without pain, and there is bony union.

CASE 6. M. C. S., female, seventy-two years of age, was admitted to the hospital on December 19, 1938. She had fallen the same day and had sustained a fracture of the neck of the left femur. Traction was applied. An operation was performed on January 3, 1939. *No plaster cast was applied.* The patient was able to sit up two days afterward, and healing took place *per primam*. The patient walks perfectly, and bony union is present.

CASE 7. I. A., female, sixty-five years of age, was admitted to the hospital on January 4, 1939, sixty days after a fall, which had caused a fracture of the neck of the left femur. She complained of pain, and it was impossible for her to walk. Traction was applied as usual. An operation was performed on January 13, 1939. *No plaster cast was applied.* The patient sat up the next day. The wound healed *per primam*. The patient walked the fourteenth day, and since then she has walked freely. Bony union is present.



FIG. 14-A

Case 5. M. P., female, aged seventy-eight years. Roentgenogram on November 17, 1938, showing fracture of neck of right femur.

1940 the patient was walking perfectly and painlessly. She had bony union with a complete range of motion.

CASE 4. J. M., male, forty-five years of age, was admitted to the hospital on September 25, 1938. Twenty days before, he had suffered a fracture of the neck of the right femur. An operation was performed on October 4, 1938. *No plaster cast was applied.* The wound healed *per primam*, and on the tenth day the patient could walk freely. Bony union was present.

CASE 5. M. P., female, seventy-eight years of age, was admitted to the hospital on November 17, 1938. Some hours before, she had fallen and had sustained a fracture of the neck of the right femur. Traction was applied as usual. An operation was performed on December 3, 1938. *No plaster cast was applied.* The next day the patient could

CASE 8. M. C. F., female, sixty-eight years of age, was admitted to the hospital on March 3, 1939. Twenty-two days previously she had fallen and had fractured the neck of the right femur. Traction was applied as usual, and an operation was performed on March 15, 1939. *No plaster cast was applied.* The patient was able to sit up the next day. Healing took place *per primam*. The patient began to walk on the sixteenth day and is now walking normally.



FIG. 14-B



FIG. 14-C

Case 5. Anteroposterior and lateral roentgenograms, showing result on January 4, 1940.

CASE 9. A. W., male, forty-one years of age, was admitted to the hospital on August 24, 1939, three days after he had sustained a fracture of the neck of the left femur. He also had advanced cardiac disease. An operation was performed on August 25, 1939. *No plaster cast was applied.* The patient sat up the next day. The wound healed *per primam*. The patient stood up on the fourteenth day and was able to walk with two canes on the twenty-fifth postoperative day. He now walks freely.

CASE 10. D. M., female, seventy-five years of age, was admitted to the hospital on December 19, 1939, with a fracture of the neck of the femur, caused by a fall the day before. Traction was applied, and an operation was performed on December 27, 1939. *No plaster cast was applied.* A small hematoma was evacuated, but healing was undisturbed. The patient was able to stand up on the fourteenth day and to walk on the twentieth day.



FIG. 15-A



FIG. 15-B

Case 7. I. A., female, aged sixty-five years. Roentgenogram on January 9, 1938, sixty-five days after fracture of neck of left femur, showing absence of reduction.

Case 7. Roentgenogram on February 24, 1939, forty-two days after operation.



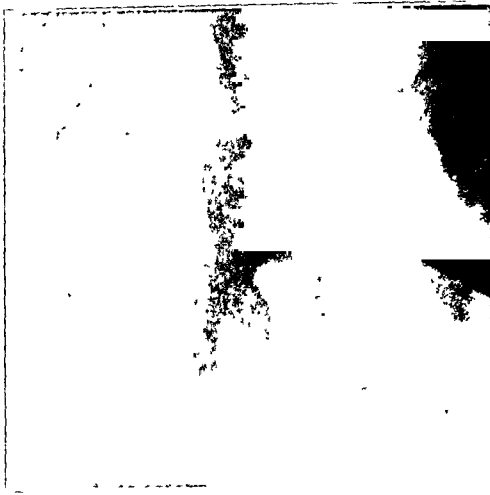


FIG. 16-A

FIG. 16-A

Case S. M. C. F., female, aged sixty-eight years. Roentgenogram on March 7, 1938, twenty-six days after fracture of neck of right femur, showing absence of reduction.

FIGS. 16-B and 16-C

Case S. Anteroposterior and lateral roentgenograms on April 11, 1939, twenty-seven days after operation.



FIG. 16-B



FIG. 16-C

#### SUMMARY

The principal characteristics of the technique for osteosynthesis of the neck of the femur which has been described are as follows:

1. A stud-bolt screw with a very sharp and high helicoid thread has been devised. The thread takes hold only in the head of the femur. The screw is cannulated, so that it may be guided by a Kirschner wire previously inserted.

2. An electric drill, also cannulated, is used. It has the great advantage of perforating the head and the neck very smoothly. In this manner, the separation or turning of the head while the channel is being made is avoided.

3. No hammering is required, and the operation produces minimal trauma.

4. As the head of the femur is so firmly held against the neck that it amounts to impaction, no rotation or flexion can take place at the site of fracture. The weak point of most of the methods previously in use has been the lack of this firm anchorage of the head of the femur.

5. *The technique dispenses with the application of a cast.* Patients are allowed to sit up in bed on the day of the operation. Eight of the author's patients were permitted to walk without a cast from nine to twenty days after operation. This shows the solidity of the synthesis. Roentgenograms taken thereafter showed no evidence of movement of the fragments. *Active motion should be instituted from the beginning.*

6. The screw has always been well tolerated, and up to the present the author never has had to operate for extraction of the screw.

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NOTE: The mechanical construction of the screw with its technical application has been described by Dr. Godoy-Moreira in *Brasil-Medico* and by Dr. O. R. Maróttoli in *Boletines de la Sociedad de Cirugia de Rosario*. Although it is not the custom of *The Journal* to publish descriptions of apparatus or technique which has been previously reported elsewhere, we are making an exception in this case, since so few of our readers have access to either of these journals.—*Editor*

# SPONTANEOUS DISLOCATION OF THE ATLANTO-AXIAL ARTICULATION, INCLUDING A REPORT OF A CASE WITH QUADRIPLÉGIA

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In recent years, there has arisen a new clinical entity, known as "spontaneous dislocation of the atlanto-axial articulation". We define this type of dislocation as one without known trauma, direct or indirect; and with no discernible organic disease of the bone. Falling downstairs is a common direct trauma, while throwing a ball forcibly is an adequate indirect one. Tuberculosis and syphilis are the usual organic offenders.

After a careful survey of the entire literature, we have compiled twenty-eight acceptable cases of true non-traumatic atlanto-axial dislocations, not associated with diseases of the vertebrae or their ligamentous attachments. These include one case of our own, complicated by a complete quadriplegia, which was treated successfully nearly two years ago and which has not recurred.

In 1908, Wittek, in reporting a case, suggested that the ligaments of the atlanto-axial joint had become distended from a "metastatic effusion" into the joint. Swanberg (1919) believed that in his case the transverse ligament of the atlas had ruptured. He was doubtful, however, that the history of this non-traumatic lesion was complete. Sudeck (1923) explained his first case as being due to excessive passive rotation under narcosis. Although his second case had a traumatic etiology, he explained it on the basis of an incoordinate reflex action. This theory Brinkmann (1928) accepted as a physiopathological factor in his non-traumatic case. In 1930, Desfosses called attention to the article of Grisel, who believed that the dislocation was due to a contracture of the suboccipital muscles, following the lymphadenitis of a nasopharyngeal infection. Berkheiser and Seidler (1931) offered as a possible explanation effusion into the joint capsule with overdistention of the ligaments, similar to the theory of Wittek. They added, however, swelling of the anterior and posterior bursae as contributory factors. Greig (1931) suggested hyperaemia, followed by decalcification (about the ligamentous attachments that hold the atlas in place) with subsequent relaxation of the ligaments and dislocation of the vertebrae. Watson-Jones (1931) joined Swanberg in his view of rupture of the transverse ligament as the cause of the dislocation. Watson-Jones stated that the condition is peculiar to children at an age when the bones are imperfectly developed and poorly

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ossified. In our case, however, the patient was well advanced in life. Coutts (1934) discussed twenty cases of "distention subluxation", but, since his article contained no case histories, it could not be used for a statistical study. Zeitlin and Odessky (1934) favored Grisel's theory. Hess, Bronstein, and Abelson (1935) combined several of the theories. They believe in spasm of the cervical muscles, associated with loosened ligaments, and they add that rotation may play a part. Frank (1936) believed in Greig's theory, but mentioned those of Berkheiser and Seidler and Grisel. Steele (1937) explained his case on the theory of distention of the bursae about the atlas, as advanced by Berkheiser and Seidler.

Several authors have presented cases deriving their origin from foci of infection. Böger (1905) reported a case of chronic rheumatic fever in a boy of seventeen; and Jacobs (1918), one of acute articular rheumatism. The latter postulates distention of the joint and relaxation of the ligaments as a result of toxins. Stammers and Frazer (1933) reported a case of non-specific arthritis, and mentioned Robert Milne, who had seen "several cases of spontaneous dislocation of this nature, mostly in young people, in association with rheumatic fever; in two cases with endocarditis". Hess and his co-authors (1935) quoted Jaksch and Coudray as reporting two cases with chronic rheumatism.

In the case of Steele (1937) there was an associated spontaneous dislocation of the hip apparently by a similar mechanism. Frank (1936) pointed out that this dislocation of the atlas may be compared to subluxation of the hip sometimes seen complicating exanthemata, typhoid, and mastoiditis. Heikkilä (1937) reported a case of dislocation of the atlas following acute epidemic parotitis.

For purposes of completeness, we think it best to mention several cases that have been freely quoted by previous authors and which we have excluded. Bell (1830) not only omitted essential data, but his case was complicated by an eroding luetic ulcer of the posterior pharyngeal wall. The cases of Corner (1907), Wittkop (1910), Black (1910), Ely (1911), Woltman and Myerding (1934), Brav (1936), Paltrinieri (1937), and Clavel and Faure (1937) have a direct traumatic history and have been discarded. Ogilvy (1913) cited a case of dislocation induced by throwing a ball. We consider this indirect trauma.

#### ANATOMY

The articulation of the atlas with the axis consists of four joints (two are pivot joints and two are arthrodial or gliding joints): (1) between the posterior surface of the anterior arch of the atlas and the front of the odontoid process, (2) between the anterior surface of the transverse ligament of the atlas and the back of the odontoid process, and (3 and 4) on both sides between the articular processes of the atlas and the axis. There is a bursa on each side of the odontoid process, separating it anteriorly from the transverse ligament of the atlas. Each of the four joints

has its own synovial membrane. The four ligaments which connect these bones are: (1) the two articular capsules, connecting the margins of the lateral masses of the atlas with those of the posterior articular surface of the axis; (2) the anterior atlanto-axial ligament, fixed from the lower border of the anterior arch of the atlas to the front of the body of the axis; (3) the posterior atlanto-axial ligament, attached from the lower border of the posterior arch of the atlas to the upper edge of the laminae of the axis; and (4) the transverse ligament of the atlas, which arches across the ring of the atlas and retains the odontoid process in contact with the anterior arch. The joint as a whole allows the rotation of the atlas (and with it, the skull) upon the axis, the extent being limited by the alar (odontoid) ligaments.

#### CASE REPORT

E. A., white, female, aged sixty-two years, a housewife, was admitted to the Metropolitan Hospital on February 7, 1938, with a history of progressive stiffness of the neck and of a respiratory infection beginning two weeks before admission. She complained of coryza, cough, and substernal pain, but there were no other symptoms. The past history revealed a hysterectomy for fibroid uterus eleven years before. The family history was negative.

Physical examination revealed a well-developed and well-nourished female with pain on motion of the neck in any direction. There was a moderate exophthalmos present, and the thyroid gland was palpable. Dullness, diminished breath sound, and decreased tactile fremitus were present at the left base in the posterior axillary line. The heart was slightly enlarged. The blood pressure was 155/76. The abdomen and extremities were normal. The superficial reflexes were hyperactive with a tendency to bilateral ankle and patellar clonus. Good strength and coordination were noted in all the extremities. The sensorium was not impaired. The diagnosis at this time was upper respiratory infection, bronchopneumonia, arteriosclerotic cardiac disease, hyperthyroidism, and possible dislocation of the atlas.

The patient remained flat in bed, complaining of severe pain in the neck and of frontal headaches, and receiving supportive treatment for the pneumonia. Blood chemistry and urine examinations were normal, and the Wassermann reaction was negative. Roentgenographic examination of the spine revealed no evidence of dislocation of the vertebrae. Studies of the skull and long bones also failed to disclose any pathology. The basal metabolic rate was repeatedly plus twenty-five. On February 19, twelve days after admission, paresis of the bladder, abdominal distention, and intestinal atony developed. On February 21, weakness of all four extremities became apparent, progressing to a quadriplegia in seventy-two hours. There was no pain other than locally in the neck. Neurological examination at this time revealed the following: (1) marked immobility of the neck; (2) complete quadriplegia (somewhat flaccid in the upper extremities and spastic in the lower), the reflexes being active with transient ankle clonus and a tendency to a Babinski reflex on the left; (3) absence of abdominal reflexes; (4) sensory changes of the radicular type in the arms; and (5) bladder and rectal disturbances. The roentgenogram (Fig. 1) showed displacement to the left of the left lateral margin of the atlas.

The patient was placed in a fracture bed with extension of the head by means of Crile head traction with six pounds of weight. An indwelling catheter was installed and hooked up to a bladder-decompressing apparatus for continual irrigation by means of boric-acid tidal drainage. The patient appeared and felt much better by the end of the first week of Crile traction. On March 4 (the end of the second week of traction) it was noted that the patient could move her fingers and lift her arms slightly. The abdomen was soft again. On March 11, the bowel function was normal.

A neurological check-up on May 5, 1938, revealed considerable regression of the symptoms and signs: The mobility in the upper extremities was well restored; active movements in the lower extremities were less limited than before, but there was still a considerable paraplegia. The spasticity in the lower extremities was also less marked. The knee jerks were only moderately hyperactive, and the ankle jerks were even somewhat diminished. No pathological reflexes could be elicited, save for a bilateral Hoffmann's sign. Sensation and coordination were intact. Bladder function was markedly improved. The hyperthyroid symptoms were as previously described and were not connected with the neurological findings.

The quadriplegia continued to subside, and the patient made a complete recovery. On June 13, 1938, the traction was removed, and the patient became ambulatory with a Thomas collar (with turnbuckles). On August 16, 1938, the patient was discharged, wearing the collar, completely cured. Postreduction roentgenograms revealed the complete reduction of the dislocation. Follow-up showed that the patient had soon discarded the collar, due to unsympathetic family pressure, but she has remained symptom-free to the present day.

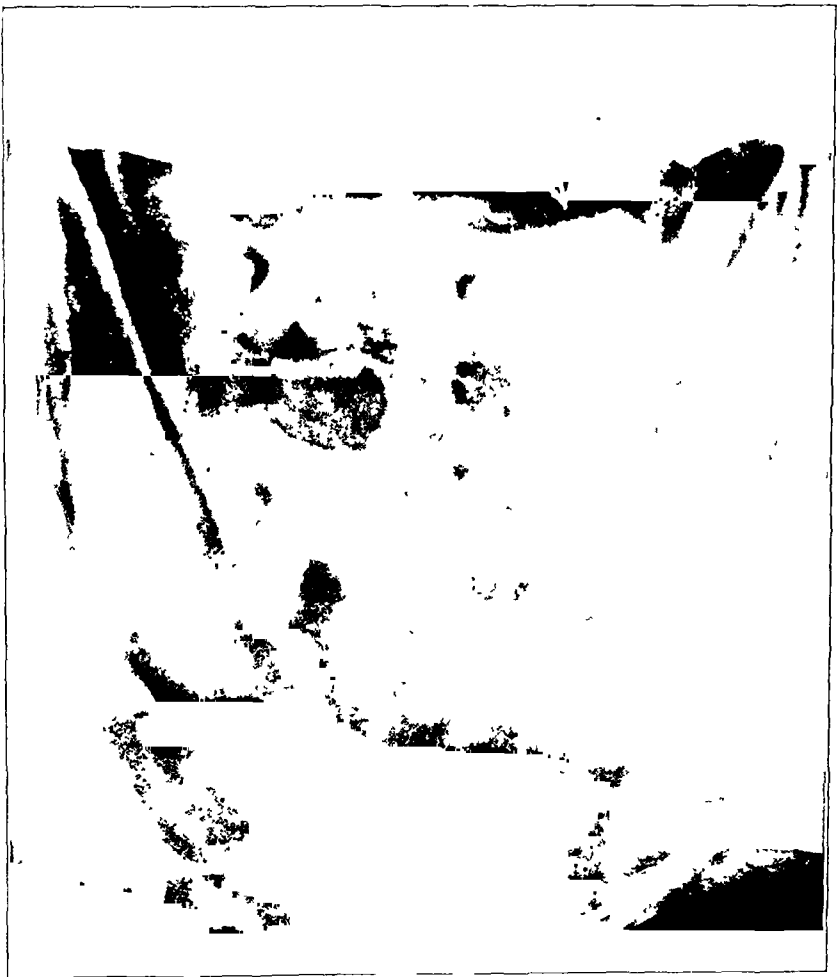


FIG. 1

E. A. Anteroposterior view of dislocation of atlanto-axial articulation.

TABLE I  
TWENTY-EIGHT CASES OF SPONTANEOUS DISLOCATION OF THE ATLANTO-AXIAL JOINT WITHOUT FRACTURE

Author	Year	Age of Patient (Years)	Sex	Predisposing Cause	Time between Infection and Involvement of Neck	Cord Involvement	Treatment	End Result
Wittek	1908	11	Male	Suppurative periostitis of left mandible, of dental origin	No known interval	None	Manipulation under anaesthesia and application of plaster cast. (X-ray showed no improvement.)	Unknown.
Fitzsimmons	1915	11	Female	Mastoidectomy	4 months	None	Successful manipulation.	Unknown.
Jacobs	1918	5	Male	Febrile illness	1 week	None	Application of Calot jacket under anaesthesia with head in hyperextension. Jacket removed after 2½ months. (Postreduction films good.)	Patient asymptomatic at 2½ months.
	1918	8	Male	Acute articular rheumatism	1 week	None	Hyperextension under anaesthesia and application of cast to be worn 2 months. (Patient stopped breathing on operating table for a while.)	Unknown.
Swanberg	1919	22	Male	Measles and acute follicular tonsillitis	1 day	None	Unsuccessful manipulation. (Attempt made to suspend body from head on a tripod.)	Unimproved.
Sudeck	1923	8	Female	Pharyngitis and suppurative cervical lymphadenopathy	Unknown	None	Manipulation under anaesthesia and application of plaster cast to be worn 6 weeks. (Postreduction film good.)	Good.
Brinkmann	1928	5	Male	None stated	None stated	None	Unsuccessful manipulation under anaesthesia.	No improvement after 2 years.
Tedesco, Grisel, Desfosses, and Tassin	1930	12	Female	Mastoiditis	1 day	None	Patient treated 2 years after onset with extension for 15 days.	Unknown.

Desfosses	1930	7	Female	Nasopharyngeal infection	1 week	None	Head traction for 2 weeks; then traction at night only for several nights.	Unknown.
Grisel	1930	8	Female	Tonsillitis	1 day	None	Head traction for 3 weeks, followed by traction at night only.	Good after 9 years.
Watson-Jones	1930	9	Female	Rhinopharyngitis	1 day	None	Head traction for several weeks, followed by traction at night only.	Good after 5 years.
	1931	9	Male	Acute mastoiditis	1 day	None	Hyperextension under general anesthesia, followed by immediate application of plaster cast to be worn 10 weeks. Exercises for 2 months.	Good (complete recovery in 4 months).
	1931	2	?	Head cold and pharyngitis	?	None		
Berkheiser and Seidler	1931	8	Female	Rheumatic fever, arthritis, and pericarditis	4 weeks	None	Head traction for 9½ months, followed by plaster collar for 3 months.	Tendency to recur (very slight improvement).
	1931	10	Female	Scarlet fever	4 days	None	Head traction for 1 month. Patient discharged with plaster collar.	Unknown.
	1931	9	Male	Acute coryza	3 weeks	None	Head traction for 2 months, followed by plaster collar for 2½ months.	Unknown.
	1931	11	Male	Cold and tonsillitis	2 days	None	Head traction for 1 month, followed by plaster collar for 2 months; this collar was replaced by a roll collar of cotton and bandage.	Unknown.
	1931	9	Female	Influenza	1 week	None	Manipulation under anesthesia with plaster cast for 12 weeks; then head traction for 2 weeks and plaster collar for 6 more weeks; then head traction at night only.	Unknown.
Roelyn-Jones	1932	10	Male	Infected tonsils and adenoids	2 to 3 weeks	None	Head traction for 7 weeks, followed by plaster cast for 15 weeks; then application of leather collar.	Unknown.



TABLE I (Continued)

Author	Year	Age of Patient (Years)	Sex	Predisposing Cause	Time between Infection and Involvement of Neck	Cord Involvement	Treatment	End Result
Stammers and Frazer	1933	20	Male	Chronic non-specific arthritis	Not stated	None	Plaster collar without attempting reduction; new cast in 6 weeks without reduction; leather collar 2 weeks later.	Very slight improvement.
Zetlin and Odessky	1934	12	Female	Parotitis and influenza	2 weeks	None	Treatment of Grisel advised, but article does not tell what was done.	Unknown.
Hess, Bronstein, and Abelson	1935	6	Male	Scarlet fever and suppurative cervical lymphadenopathy	2 weeks	None	No treatment.	Unknown.
	1935	11	Female	Head cold	1 week	None	Head traction followed by plaster cast.	Good clinically and by x-ray in 6 weeks.
Chesterman	1936	10	Female	Tonsillitis	1 day	None	Extension (head traction) for 2 months; Jones collar for 5 months.	Unknown.
Frank	1936	9	Male	Retropharyngeal abscess and cervical adenitis	11 days	None	Head traction followed by plaster cast.	Good clinically and by x-ray in 6 weeks.
Steele	1937	7	Male	Adenoidectomy and furunculosis	Not stated	None	Plaster cast under general anaesthesia.	Unimproved.
Heikkilä	1937	17	Male	Parotitis	1 month	None	Treated by roentgen ray.	Very slight improvement.
Wilson, Michele, and Jacobson	1940	62	Female	Respiratory infection	1 week	Complete quadriplegia with bladder and rectal disturbances	Head traction for 4 months; Thomas collar for 2 months.	Good clinically and by x-ray. No recurrence after 2 years.

## DISCUSSION

An analysis of Table I reveals the following:

1. The sex incidence of the twenty-eight cases is evenly divided.

2. The majority of the cases in the literature fall between the age groups of five and twelve years. The youngest patient was two years old, and the oldest (outside of our own) was twenty-two. Our case is unique in that the patient, at the age of sixty-two, is outside of this grouping.

3. It is difficult to evaluate the latent period between the onset of the predisposing infection and that of the neck involvement, because many of the authors did not see their patients until an appreciable interval of time had elapsed.

4. Our case is the only one of the series in which there was spinal-cord involvement. The patient had a complete quadriplegia with bladder and rectal disturbances.

TABLE II

SUMMARY OF TREATMENT AND RESULTS IN THE TWENTY-EIGHT CASES ANALYZED IN TABLE I

Treatment	Results				
	Good (Cases)	Poor (Cases)	Unimproved (Cases)	Unknown (Cases)	Total (Cases)
Head traction . . . . .	2	0	0	3	5
Manipulation . . . . .	0	0	2	1	3
Plaster cast . . . . .	0	1	1	0	2
Head traction (such as Crile type) followed by collar or cast . . . . .	3	1	0	5	9
Manipulation under anaesthesia followed by collar . . . . .	4	0	0	3	7
Miscellaneous . . . . .	0	1	0	1	2
Total . . . . .	9	3	3	13	28

Table II, condensed from Table I, shows that two of the nine patients with known good results had been treated by means of head traction; and that seven had had retentive cervical collars after reduction of the dislocation. It is our opinion that the use of head traction is the least traumatizing and the most satisfactory form of treatment, especially if quadriplegia complicates the clinical picture.

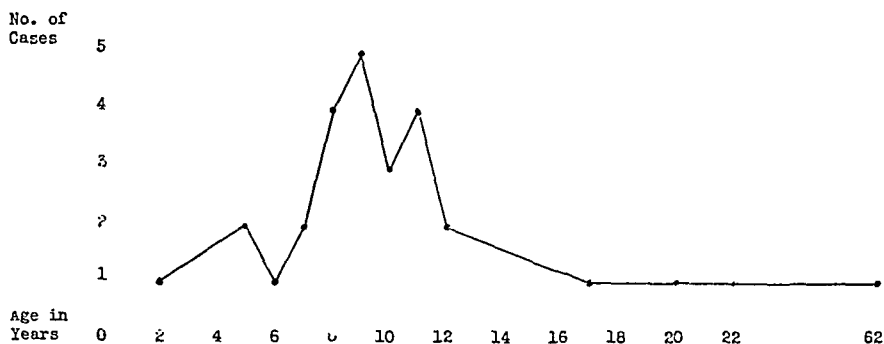


FIG. 2

Relationship between the number of cases and the ages of the patients.

### SUMMARY AND CONCLUSIONS

1. Analysis of the twenty-eight cases of spontaneous dislocation of the atlanto-axial joint, not complicated by fracture or by organic disease of the vertebrae, which have been collected shows that the sex incidence is equally divided. The age incidence ranges from two to sixty-two years, with the greatest peak in childhood.

2. The dislocation is preceded by an antecedent infection, most often of the nose or throat, but which may be one of the exanthemata, rheumatic fever, or mastoiditis.

3. Head traction is the best method of reduction and should be followed by a plaster or Thomas collar.

4. Our case is unique in that the patient was an adult of sixty-two in whom there had developed a complete quadriplegia amenable to treatment. The postreduction films showed a good reduction, and a two-year follow-up revealed that there had been no recurrence.

5. Of the many theories offered, that of Berkheiser and Seidler is the most logical in our minds. However, there is one factor that appears to be overlooked,—that is, the probability of an intrinsic factor in the vertebrae. Many people have respiratory infections each winter, yet the incidence of spontaneous dislocation of the atlas is comparatively rare. Adequate post-mortem examination would settle this point. In the absence of this evidence, however, a satisfactory explanation of the pathological process behind the disease must remain lacking.

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# HERNIATION OF THE INTERVERTEBRAL DISC WITH REFERRED SCIATIC SYMPTOMS

## A STUDY OF FORTY CASES \*

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Low-back pain associated with sciatic radiation and positive signs is a combined neurological and orthopaedic problem which necessitates a close cooperative study in these overlapping fields. The syndrome of herniation of the intervertebral disc is quite characteristic when critically analyzed both from the clinical and from the laboratory aspects. This paper is based on a study of forty cases which present this low-back problem for differential diagnosis. Lipiodol has been used as a contrasting medium for myelographic studies in our series of cases inasmuch as the injection of air for this purpose has not proved satisfactory.

When a reasonably positive diagnosis has been made and when intractable sciatic pain persists in spite of conservative measures, such as traction, immobilization, and physical therapy, the treatment is clearly operative. A laminectomy confined to two laminae on the side of the lesion, thus producing minimal trauma to the spine, gives adequate exposure when definite localization has been possible. In our series of operated cases a hemilaminectomy was performed in all but two. In the one case in which the final diagnosis was that of arachnoiditis, an extensive laminectomy was necessary in order to rule out other intraspinal pathology, and this was followed by spine fusion. After removal of the laminae, the dura is carefully rolled to one side and the herniated tumor comes into view, usually in intimate contact with the nerve root, which shows the compressive sign. By careful retraction of the dura and its contents, the irregular fibrous mass is dissected free. This often is quite difficult and painstaking, the material being removed piecemeal, although occasionally a well-encapsulated mass is encountered. Before closure of the wound, the dura and the arachnoid membranes are opened, permitting escape of as much lipiodol as possible. This requires elevation of the head of the table, in order to bring the heavy oil into the dependent position, and suction with the usual apparatus for this purpose.

The question of spine fusion following laminectomy has arisen on several occasions, and this procedure has been carried out by us in two of the cases in this group. Where a hemilaminectomy is done, involving only two or three laminae on one side, without disturbance of the pedicles or articulating facets, it is our opinion that spine fusion is unnecessary. However, in cases of abnormal anatomy and structural weakness in the low lumbar region, the stabilizing operation is clearly indicated.

\* Presented at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Memphis, Tennessee, on January 17, 1939.

In cases where the diagnosis is quite definite and in which, for various reasons, surgical attack is not permissible, conservative care may give relief. Traction and trunk flexion, followed by hyperextension, may reduce some of these herniations. Symptomatic relief is then frequently obtained by a period of immobilization.

The following six case histories are given in some detail as they present important points in differential diagnosis and treatment.

#### CASE REPORTS

**CASE 1.** E. G. C., male, aged thirty-eight years, was first seen on March 18, 1937, with a history of low-back pain of approximately seven years' duration. There was no history of injury. Following a tonsillectomy, the patient had had a remission until the summer of 1936, when left sciatic pain developed and persisted. At that time several infected teeth were removed, with no relief.

Examination on March 18, 1937, disclosed a trunk list to the right, with all motions of the spine guarded. There was tenderness localized to the region of the left greater sciatic notch. Hypaesthesia was noted over the distribution of the superficial peroneal nerve with diminution of the left ankle reflex. Roentgenographic study of the spine disclosed minor arthritic changes.

Early treatment consisted of a period of fixation in a skeletal back brace and physiotherapy. No relief was obtained, and eight weeks later spinal puncture was performed. The cell count and manometric readings were normal, with a total protein of twenty-four milligrams per 100 cubic centimeters. Lipiodol injection was done, and a defect was noted in the left lumbar region at the level of the fourth intervertebral disc.

On May 19, 1937, a hemilaminectomy was performed (Dr. J. J. Keegan), in which the fourth and fifth laminae on the left side were removed. A definite protruding mass was found at the site of the defect in the lipiodol studies, which produced compression on the fifth lumbar root. The immediate postoperative condition was excellent, with disappearance of symptoms in one week. The patient has been under observation for three years and is symptom-free, working actively as a telephone-operator supervisor, which requires long hours of standing. He also states that he has been riding horseback with no untoward symptoms.

*Comment:* This case illustrates the typical history, course, and outcome of these lesions.

**CASE 2.** H. G., female, aged thirty-two years, a laboratory technician, was first seen in May 1936, when pain developed in the low back, with radiation into the left thigh. Symptoms were aggravated by forward flexion and walking, but were only intermittent during the first year. Six months after onset, she was forced to discontinue her work.

In July 1937, her tonsils were removed, and a hip spica cast was applied. Examination at this time, including detailed roentgenographic studies, was essentially negative, except for a positive Lasègue's sign. Neurological examination, on July 25, 1937, revealed absence of the left ankle reflex and weakness of dorsiflexion of the toes on the left side. Sensory changes were not definite. Laboratory findings disclosed a clear spinal fluid with a cell count of 2, normal pressure, and no evidence of block. The total protein content was five milligrams per 100 cubic centimeters.

The patient returned to the hospital on September 16, 1937, with persistent left sciatic pain and positive neurological findings. Intraspinal lipiodol injection, on October 4, 1937, disclosed a protruding mass on the left side at the lumbosacral junction.

Laminectomy was performed on October 9, 1937 (Dr. J. J. Keegan) with removal of a herniated disc at the fifth lumbar intervertebral space. The end result was very gratifying. The patient was symptom-free within two weeks, and, in a recent follow-up

letter, she reported complete relief of symptoms for the past two years and stated that she had been working actively as a technician.

*Comment:* In spite of early neurological findings, conservative treatment was recommended. Due to overconservatism and failure to appreciate the positive findings earlier, disability was prolonged approximately one year.

CASE 3. R. L., male, aged thirty-five years, was first seen on November 5, 1938, with a history of a twisting injury ten months previously, when he had felt and heard a snap in the low back as he was reaching for the hand brake of a traction plow. Back pain was severe and persistent. Within six weeks, referred pain had developed along the course of the left sciatic nerve, and there was a marked trunk list. Early treatment had consisted of osteopathic manipulations, visits to springs, check-up on foci, and a period of bed rest. His tonsils had been removed, and he had had the usual dental repair.

Examination on November 5, 1938, showed a healthy young man with a marked postural scoliosis to the right. All motions of the spine were greatly limited. Straight-leg raising on the left side was limited to 30 degrees, with severe sciatic pain. The left ankle reflex was absent, and definite hypaesthesia was noted over the lateral aspect of the left foot and ankle. Roentgenographic examination of the lumbar spine was negative. Neurological examination, followed by spinal puncture and lipiodol injection with fluoroscopic study, disclosed a characteristic defect in the fourth intervertebral space on the left side (Figs. 1, 2-A, and 2-B).

Treatment consisted of hemilaminectomy on November 9, 1938 (Dr. J. J. Keegan and the author). A flat, irregular mass was found just anterior to the fourth and fifth lumbar roots. The patient was discharged from the hospital on November 25, 1938, two weeks after operation. There was no sciatic pain, but the patient complained of some discomfort in the low back. When last seen, on May 15, 1939, six months after operation, the patient stated that he had had only occasional pain in the posterior aspect of the thigh, but he had experienced no back pain. He had gained ten pounds in weight since discharge from the hospital. Examination disclosed a straight spine with three-fourths of the normal range of motion. The sensory disturbance over the lateral aspect of the leg had disappeared, but the tendo achillis reflex was still absent.

*Comment:* The sharp defect noted in the roentgenogram was out of proportion to the operative findings, as the disc was protruding uniformly rather than herniating as a discrete mass. The end result one year after operation is entirely satisfactory.



FIG. 1

Case 3. Showing sharp defect at the fourth intervertebral space on the left side. Relief followed laminectomy.

CASE 4. J. J. S., male aged forty-eight years, was first seen by the author on March 26, 1938.

He stated that on February 22, 1936, while carrying a heavy case down stairs on his right shoulder, he had fallen backwards, striking his back and lower right thigh. He slid down the steps and was partially dazed, but was able to get about in a few minutes, continuing work the remaining hours of the day. On the third day, he was seen by a physician. A diagnosis of back strain was made, and the patient was given massage and strapping. After three days of work, he found it necessary to discontinue. The back was strapped continuously, and he tried on several occasions to return to work. Neurological examination in the early part of 1936 disclosed no change in reflexes or in sensation. The condition was considered as a combination of contusion of the spine and osteo-arthritis with low-back pain and referred sciatica.

Examination on March 26, 1938, disclosed a trunk list to the left, forward flexion three-fourths of the normal, hyperextension greatly limited, and lateral motions complete. The patient complained of tenderness over the right lumbosacral region. Straight-leg raising was painful at 45 degrees. A check-up of reflexes and sensations disclosed no alterations at that time. Roentgenographic examination revealed an angulation of the lumbar spine at the level of the second segment, with rather extensive productive changes about the margins of the second and third lumbar vertebrae and some narrowing of the vertebral body of the second on the left side. Our opinion at that time was that the chief difficulty was an extensive osteo-arthritis, with a questionable lateral compression of the second lumbar vertebra, which probably antedated the injury, as the latter produced only partial disability. Further examination in August 1938, thirty months following injury, disclosed for the first time an absence of the right ankle jerk. On account of persistent



FIG. 2-A

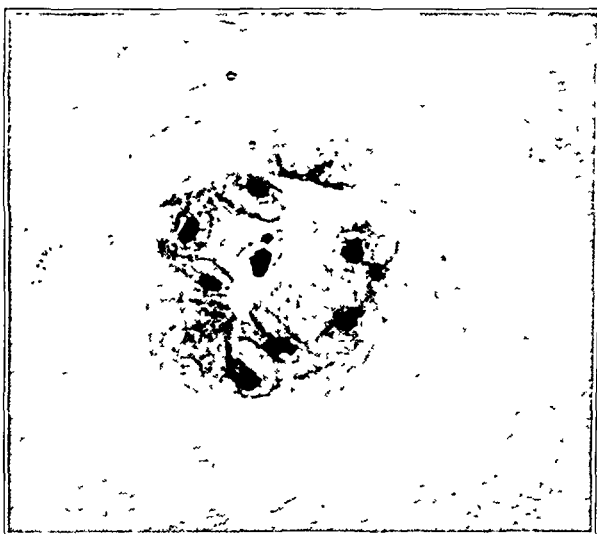


FIG. 2-B

CASE 3. Microscopic section of typical herniated disc. Note atypical cartilage cells and dense fibrous tissue.

Fig. 2-A: Low power.

Fig. 2-B: High power.



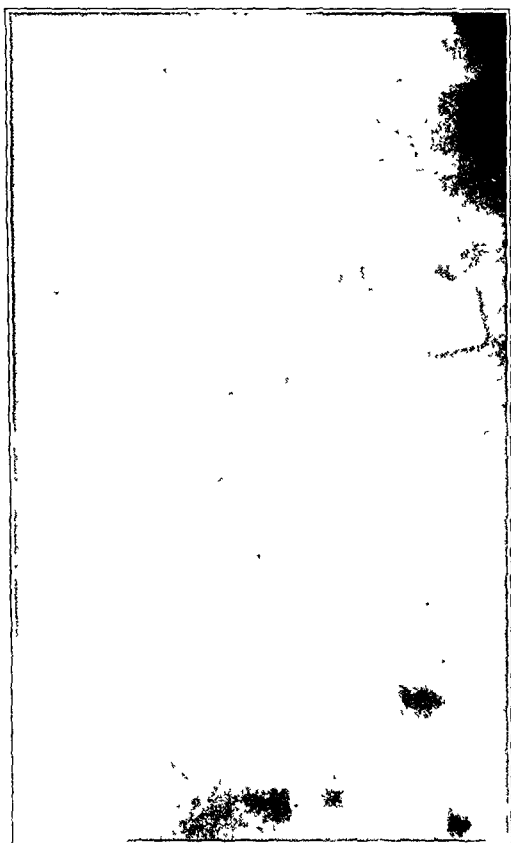


FIG. 3

Case 4. Showing failure of lipiodol to fill completely the caudal sac. Herniated disc found at fifth intervertebral space.

symptoms, in spite of a period of immobilization, spinal puncture and lipiodol injection were recommended. The spinal fluid showed no abnormal changes, the protein content being one milligram per 100 cubic centimeters. Roentgenographic studies disclosed a defect in the region of the fifth lumbar disc (Fig. 3).

On November 12, 1938, a hemilaminectomy was performed (Dr. J. J. Keegan), and a definite herniation was found at the site of the defect, as noted in the lipiodol study. The low-back pain and referred sciatic symptoms disappeared in less than one week. Eight months following operation, the patient was symptom-free and had returned to work.

*Comment:* The study of this case is of particular importance in that there was the matter of compensation throughout. With negative neurological findings, special tests were not warranted until in the middle of 1938, although the herniation of the disc undoubtedly had been present since the injury in 1936. An earlier exploratory laminectomy would unquestionably have shortened

this patient's disability several months and decreased the economic loss by several thousands of dollars. Compensation courts and insurance carriers are reluctantly accepting this lesion as compensable, although in three of our cases, final decision by judge or jury was necessary.

CASE 5. C. P., male, aged forty-one years, was first seen on January 15, 1934.

He reported that a "catch" in the left lumbar region had developed while he was lifting heavy machinery in 1931, and he was kept in bed for one month. Mild symptoms had persisted for three years, and then had gradually increased in severity. A back brace, applied in 1934, gave complete relief for six months. On October 5, 1937, while swinging a heavy sledge hammer, the patient experienced acute back pain. There was a gradual increase in symptoms with radiation into the left leg, and he was totally disabled at the end of one month with left foot drop.

Examination for compensation carriers on November 16, 1937, disclosed the significant findings of paralysis of the dorsiflexors of the left foot, paraesthesia extending up to the mid-leg laterally, and loss of the left ankle reflex. Spinal-fluid studies disclosed an initial pressure of fourteen millimeters of mercury, with normal response to jugular compression. There was a cell count of 5; the protein content was twelve milligrams per 100 cubic centimeters; and the Wassermann reaction was negative.

Roentgenograms of the lumbar spine revealed a congenital defect and osteo-arthritis involving the articulations of the fifth lumbar vertebra. Lipiodol injection disclosed a

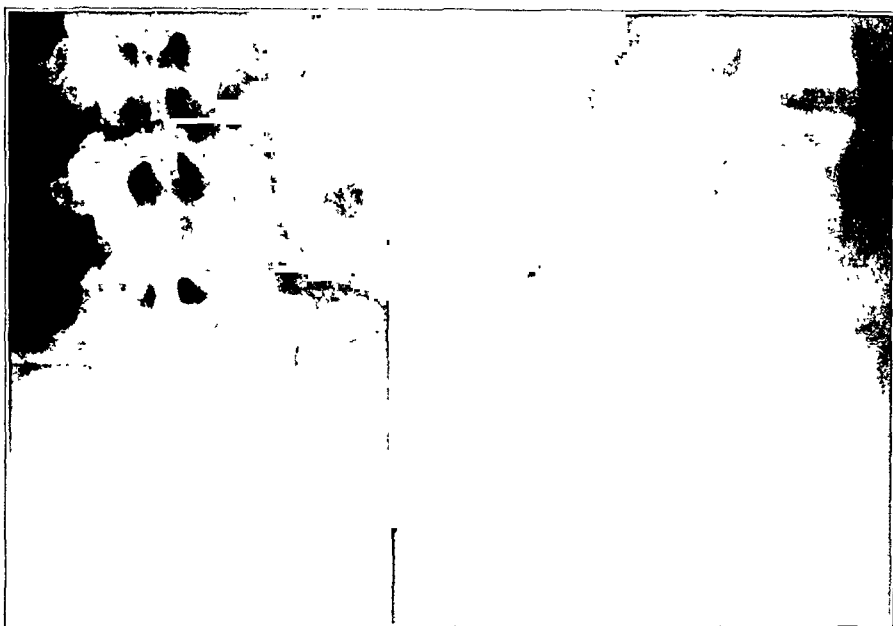


FIG. 4-A

FIG. 4-B

Fig. 4-A: Case 5. Congenital abnormality of fifth lumbar vertebra with defect in the lipiodol shadow at the fourth intervertebral space on the left side.

Fig. 4-B: Postoperative roentgenogram (one year) showing very satisfactory graft bridging sacrum and lower lumbar segments.

filling defect at the level of the fourth lumbar intervertebral disc on the left side (Fig. 4-A).

On February 2, 1938, lumbar laminectomy and spine fusion were carried out (Dr. J. J. Keegan, Dr. R. D. Schrock, and the author), in which the herniated disc on the left anterolateral wall of the spinal canal at the level of the fourth intervertebral disc was removed. Tibial grafts were placed over a layer of soft tissue covering the dura, extending from the denuded sacrum to the third lumbar vertebra.

Examination on February 4, 1939, one year after operation showed a slight foot-drop gait. The dorsiflexors of the foot had recovered two-thirds of their normal strength with complete return of sensation. Roentgenographic examination showed satisfactory bridging of the lumbosacral spine by the tibial grafts (Fig. 4-B).

*Comment:* The marked neurological findings at first examination made the indications clear, but a ten weeks' delay occurred because of failure to obtain authority from the insurance carriers for the operation.

CASE 6. L. F., male, aged thirty-four years, was seen on November 1, 1937. He stated that, at the age of eighteen years, he had experienced a sharp, stabbing pain in the low back when lifting a heavy weight. He remained in bed for one week. Since that time, he had had pain whenever he attempted to lift anything or to bend forward. Recently the pain had been more constant, radiating into both hips and down toward the heels.

Examination of the spine showed no gross deformity, with the exception of some flattening of the lumbar spine. All motions were guarded, especially forward flexion. The patient complained of tenderness over the lumbosacral area. Examination of the lower extremities revealed a definite reduction in the left ankle reflex and an area of slightly reduced pain sensation over the lower lateral surface of the left leg and ankle, and the dorsum of the foot. Roentgenographic examination disclosed a first-degree spondylolisthesis with a defect through the isthmus of the posterior arch of the fifth

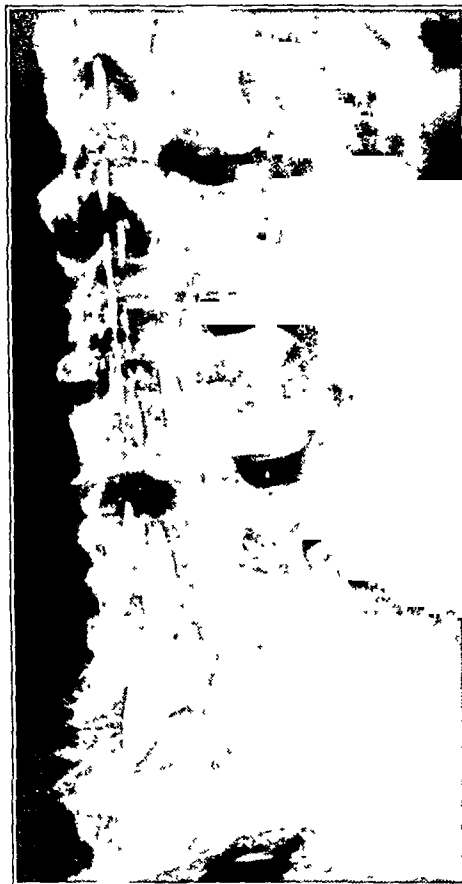


FIG. 5-A



FIG. 5-B

Fig. 5-A: Case 6. Oblique view, before operation, illustrating lipiodol shadow suggestive of arachnoiditis.

Fig. 5-B: Lateral view, six months after operation, showing fusion of the lumbosacral spine.

lumbar vertebra. Lipiodol myelography showed failure of the oil to pass above the upper level of the second lumbar vertebra, although it descended into the caudal sac. No definite filling defects were recognized (Fig. 5-A). The spinal fluid showed a cell count of 38, with normal protein content.

Due to the mechanical disturbance in the lumbosacral region, a period of conservative treatment was carried out in the form of traction to the left lower extremity, followed by a hip spica for six weeks. There was little or no relief of symptoms. Laminectomy was performed (Dr. J. J. Keegan) on December 11, 1937. Through an incision over the spines of the last three lumbar vertebrae, the laminae of the fourth and fifth lumbar vertebrae were removed. There was slight fullness of the dural sac between these vertebrae, with evidence of constriction at the level of the fifth lamina, but no herniated disc was found. The arachnoid membrane was more opaque than normal, and, upon being incised, adhesions were noted about the nerve roots of the cauda equina, which were banded together, but were easily separated. There was temporary relief of pain, but disability persisted. Roentgenographic examination, on February 17, 1938, disclosed absence of the laminae of the second, third, fourth, and fifth lumbar vertebrae, with increased forward displacement of the fifth lumbar on the sacrum. Neurological signs were positive.

At operation, on May 12, 1938 (Dr. J. J. Keegan and the author), the cauda equina was explored up to the level of the second lumbar vertebra, but no intraspinal pathology

TABLE I  
ANALYSIS OF FORTY CASE STUDIES

Number of Cases Studied.....	40
Operated.....	24
Male.....	15
Female.....	9
Non-Operated.....	16
Male.....	15
Female.....	1
Age:	
Range.....	17 to 65 years
Average.....	41 years
Etiology:	
Traumatic.....	62.5 per cent.
Mechanism:	
Hyperflexion.....	12
Twisting.....	5
Direct blow.....	7
Spinal puncture.....	1
Duration of Symptoms:	
Range.....	2 weeks to 40 years
Average.....	5 years plus
Positive Neurological Findings:	
Operated cases.....	19 or 79.17 per cent.
Non-operated cases.....	11 or 68.75 per cent.
Spinal-Fluid Readings:	
Protein content above normal.....	65 per cent.
Cell-count range.....	0 to 38 cells
Normal count.....	95 per cent.
Lipiodol Studies:	
Operated cases.....	24
With defects.....	22
Level fifth lumbar.....	6
Level fourth lumbar.....	10
Other levels.....	6
With no defect.....	2
Non-Operated.....	16
With defects.....	7
With no defect.....	6
Not injected.....	3
Treatment:	
Laminectomy.....	22
Laminectomy and fusion.....	2
Postoperative Diagnosis:	
Herniated discs.....	14
Nucleus pulposus.....	1
Combined disc and ligament.....	1
Hypertrophied ligamentum flavum.....	7
Arachnoiditis.....	1
Epidural venous varix.....	1
No pathology.....	1
End Results* in Operated Cases:	
Complete relief.....	20 or 83.33 per cent.
Partial recovery.....	3 or 12.50 per cent.
No improvement.....	1 or 4.17 per cent.

\* Average length of time since operation approximately two years.

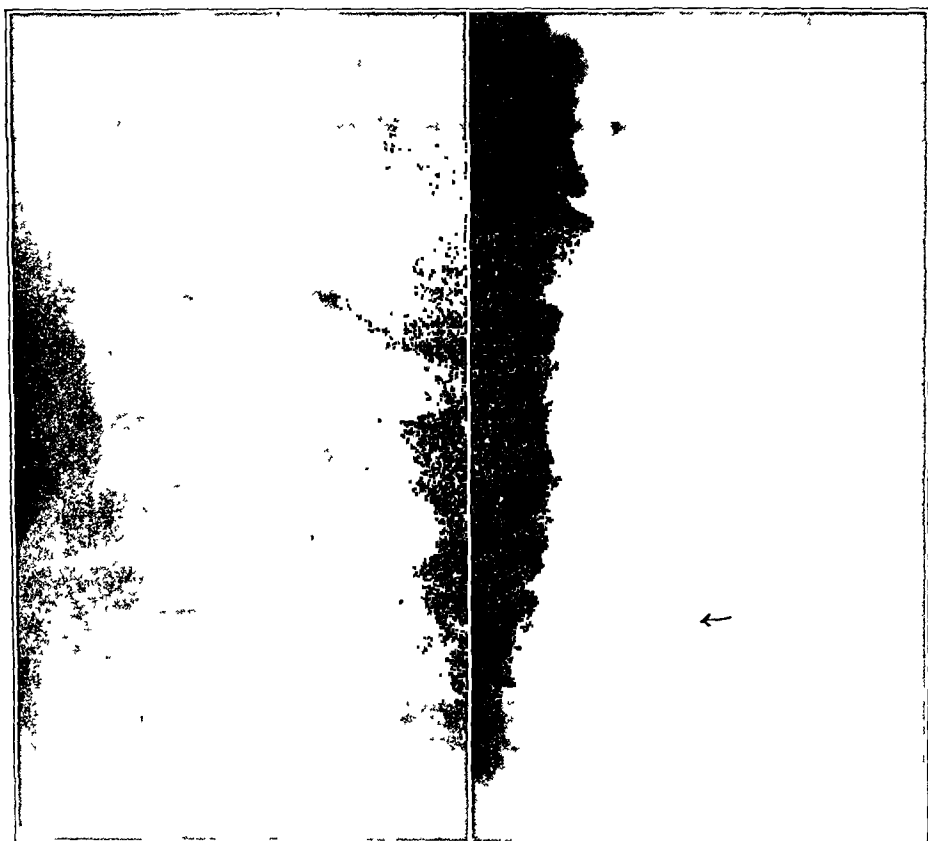


FIG. 6

Hour-glass defect, characteristic of hypertrophied ligamentum flavum. Diagnosis verified at operation.

was found. Long, slender tibial grafts were placed from the spinous processes of the upper lumbar vertebrae across to the sacrum. The patient was discharged from the hospital three weeks after operation, wearing a plaster jacket; he was instructed to remain in bed for eight weeks.

Examination six months after operation revealed a moderately rigid, painless back. The patient stated that he was able to do light work. Roentgenographic examination (Fig. 5-B) disclosed a satisfactory osseous bridge extending from the sacrum to the upper lumbar spine.

*Comment:* This case presents a complicated situation in which the final diagnosis was congenital abnormality of the lumbosacral spine and arachnoiditis. The adhesions noted in the nerve roots of the cauda equina were probably due to old hemorrhage from the trauma sustained several years previously.

#### CONCLUSIONS

1. In patients presenting symptoms of low-back pain and peripheral-nerve changes, an intraspinal compressive lesion should always be borne in mind.
2. The final diagnosis not infrequently is made at the time of the exploratory laminectomy, this procedure then being a combined diagnostic and therapeutic measure.

# THE SURGICAL TREATMENT OF DEGENERATIVE ARTHRITIS OF THE KNEE JOINT \*

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In common with the majority of physicians, we have considered the results of the treatment of degenerative (hypertrophic) arthritis of the knee joint to be unsatisfactory. The therapy employed has been essentially conservative in character, comprising many different procedures and manoeuvres, all based on the principles of rest, physiotherapy, and improving in so far as possible the mechanics of weight-bearing. Often under treatment the patient has been relieved, but, as a rule, only until he resumes normal activity when the knee symptoms have recurred, sometimes with surprising rapidity.

Because of these unsatisfactory therapeutic efforts in a relatively consistent clinical picture of knee-joint involvement, and because of the occasional opportunity to correlate clinical findings with actual joint pathology observed when synovectomy was performed, the surgical procedure to be described was planned and has been carried out with most encouraging results. Therefore, we now believe that in selected cases, which exhibit disability from degenerative arthritis of the knee joint, surgery is the preferred method of treatment.

## PATHOLOGY AND CLINICAL DATA

Most significant are the gross and microscopic studies of Keefer, Parker, Myers, and Irwin on 100 knee joints from seventy-seven consecutive necropsies. Death had resulted from a variety of causes, and the cases were not selected on the basis of previous clinical diagnosis or the presence of symptoms in the joints. Anatomical changes were seen with increasing frequency with advancing age, and after thirty between 66 and 100 per cent. of all the knee joints revealed gross anatomical changes. These abnormalities were most frequently observed at the points which were in turn subjected to the greatest movement, weight, and pressure. In particular the authors noted that degenerative change was most often found at the median horizontal facet of the patella and along the patellar groove of the femur. In other words, the two regions of the knee that most frequently exhibit degenerative arthritis are in relation to the patella.

These authors observed that on gross examination the character of the degenerative lesions varied from slight fibrillation of cartilage to thinning and erosion of the cartilage and exposure of the subchondral bone.

\* Read at the Annual Meeting of the American Orthopaedic Association, Kansas City, Missouri, on May 7, 1940.

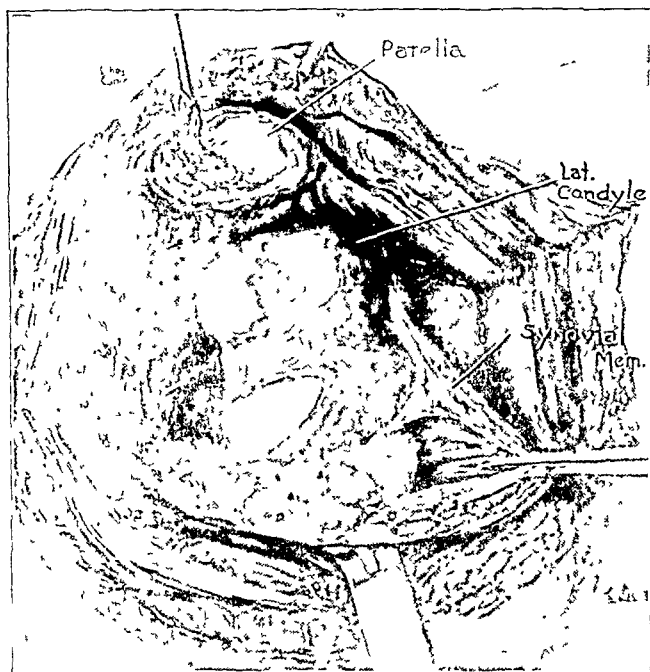


FIG. 1

Artist's drawing made at operation to illustrate the pathology seen in advanced degenerative arthritis of the knee. There is widespread erosion with degeneration of the articular cartilage, especially along the patellar groove of the femur, as well as a marked hyperplasia of the synovial membrane.

described—that is, degenerative arthritis—was due to various factors, such as aging of tissue, wear and tear, strain, trauma, occupation, and static deformities.

Key and Bauer and Bennett have reported able experimental work, which demonstrates that the pathological picture of degenerative arthritis can be produced by mechanical insults to a joint, and this further supports the hypothesis “that degenerative arthritis results from frequent trauma to opposing articular surfaces”.

Our clinical observations indicate that degenerative arthritis of the knee joint begins at the third decade, but it is occasionally observed in younger individuals who have sustained severe trauma to the knee or in whom the joint has been exposed to excessive stress and strain. These patients with degenerative arthritis of the knee joint are usually overweight, and the musculature of the extremities is often inadequate, because of the constant discomfort in the joint and the subsequent effort to protect the articulation. Swelling of the knee region is frequently observed,—a result of hyperplasia of the synovial membrane, together with the presence of increased synovial fluid. On palpation during motion, crepitation beneath the patella is a common observation, while passive motion of that bone is often painful. Patients locate the pain and tenderness in the anterior knee region, usually centered about the patella. Persistent flexion contracture is observed, while the limitation of normal

Microscopic study revealed that an early change was splitting of the cartilage, followed by depression of the underlying subchondral bone, which then altered the contour of the normal joint line. When the cartilage was completely destroyed and the subchondral bone was injured, the latter attempted repair by new-bone formation. Exostoses were formed by alteration in the normal joint line, due to compression and flattening of the joint surface. These authors, therefore, concluded that the anatomical change de-

flexion is due to pain and to swelling of the soft parts with increased joint fluid. The disability is often very pronounced.

Roentgenograms of these knee joints have consistently shown degenerative changes about the patella when such evidence of arthritic reaction was not always so readily visible in other parts of the articulation. In some instances the patella has been enlarged, with marked exostoses, particularly on the proximal and distal ends of the bone (Fig. 6-A). A narrowed joint space is often seen. The roentgenograms are remarkable, in that they rarely give an accurate idea of the degree of degenerative change which is actually present. There is no indication in these films of the extent of erosion of the cartilage, particularly of the femur and of the patella, that has so consistently been seen at operation. This observation is confirmed by the experimental work of Lachmann, who has demonstrated the limitations of roentgenographic diagnosis of destructive lesions of the knee joint by illustrating that not all osseous defects are visible on the roentgenogram, in either frontal or profile views, unless they are of minimum size.

The pathology shown at operation in a severely involved knee is illustrated in Figure 1. Attention is called to the marked hyperplasia of the synovial membrane; to the erosion of the articular cartilage, particularly over the femoral condyles; to the thinning and fibrillation of the cartilage of the patella, as well as to the hypertrophy of this bone. Besides actual erosion, there was relatively widespread degeneration of the articular cartilage, with frequent exposure of the subchondral bone, which, in turn, was eburnated. The most pronounced degeneration of the femoral cartilage was consistently found in the patellar groove. In five patients the exostoses along the margin of the femoral cartilage impinged upon similar exostoses on the articular surface of the tibia.

Without exception, all individuals who submitted to operation had previously undergone a course of conservative treatment in the Clinic, which, in conjunction with the medical supervision given elsewhere, represented a period of conservative therapy of from three to ten years. As a result of our surgical experience and the degree of function that has been obtained, we now feel that a prolonged course of preoperative conservative treatment is not necessary in these cases. At the present time each patient on admission is given a careful general medical examination in addition to the orthopaedic survey. Preliminary treatment—such as weight reduction, muscle training, and development of muscle tone—is then instituted, and the same regimen is continued after operation.

#### SELECTION OF PATIENTS

An outstanding requirement in patients submitted for knee surgery is that they impress the examiner as being cooperative: that they will, in so far as he can tell, carry out the initially painful and often wearisome exercises, and that they will faithfully adhere to the regimen of progressive activities and remain on their diet,—all essential factors in the postoperative stage of treatment to achieve a satisfactory end result. The



necessity of such cooperation cannot be too strongly emphasized. In the twenty cases here reported, the time from operation until the patient was no longer under active office supervision averaged three months.

#### EXCISION OF THE PATELLA

Since we share the opinion that "degenerative arthritis of the knee joint is the result of wear and tear, of increasing age and repeated trauma, which may be caused in a variety of ways, and is not the result of an inflammatory process, metabolic disturbance, or endocrine dysfunction", and because of the inability of articular cartilage to regenerate, and, finally, since by clinical, pathological, and roentgenographic examinations

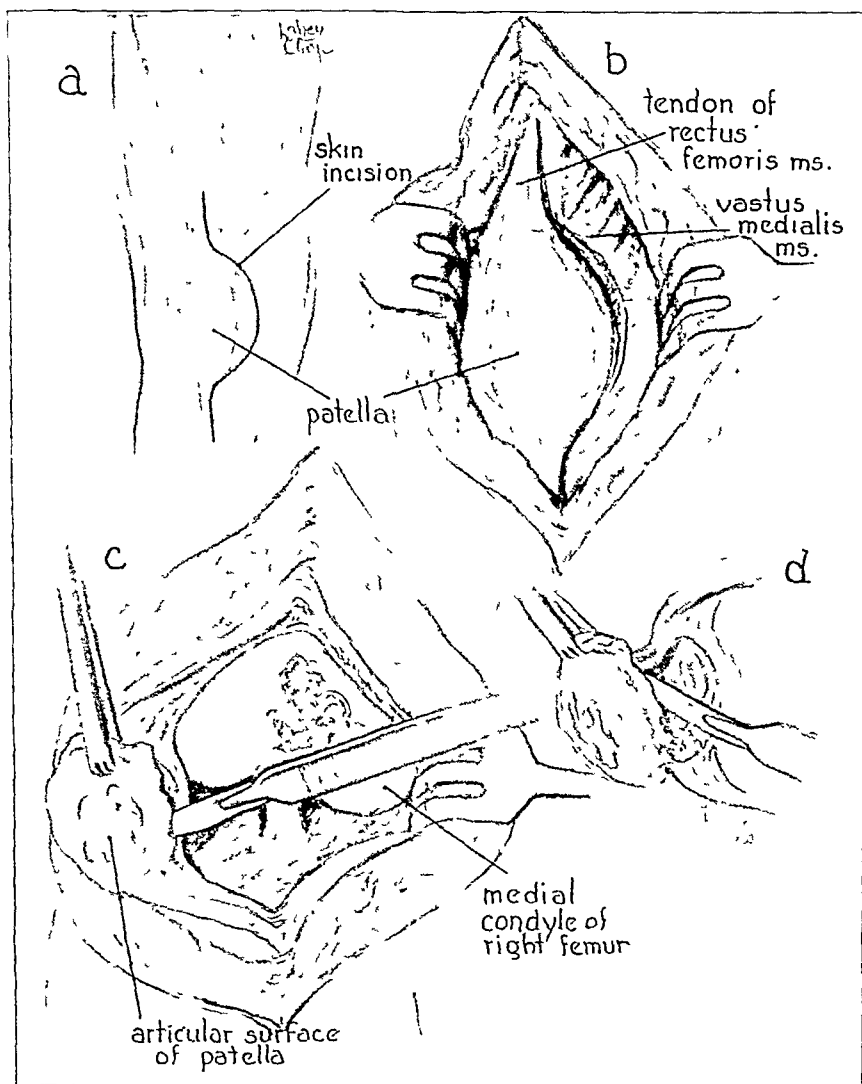


FIG. 2

The median parapatellar utility incision which permits wide exposure of the joint. After rotation, the patella, the articular surface anterior, may be readily dissected free from the underlying tendon and removed.

the most frequently affected area in the knee joint is in relation to the patella, it appeared to be a reasonable thesis that, if the patella were markedly reduced in size or removed, there would follow an appreciable diminution in clinical symptoms, with consequent improvement in function.

Was the patella essential to normal function of the knee joint? All authorities consulted indicated that such was the case. Hence, our initial operative efforts on the patella were confined to a form of "patellaplasty" (Blodgett and Fairchild), which entailed pronounced reduction in its size and covering the articular surface at first with fascia and later leaving such a thin wafer of the bone that it could be covered with plications of the extensor tendon. It was not until 1935, when we learned of the functional results which followed total excision of the patella for fracture, as performed by Brooke in a large series of cases which he reported in 1937, that this step in the operation became routine.

Excision of the patella is not a new procedure, as C. L. Scudder, in 1898, reported a case of comminuted fracture of this bone, which was treated by removal of all the fragments; and a similar operation was carried out by C. C. Rogers in 1908. Furthermore, in 1938, Tippet briefly reported the results of excision of the patella for osteo-arthritis in two patients, with good functional results, four and five months, respectively, after operation.

As a result of his studies on removal of the patella, Brooke pointed out that this bone is an integral part of the skeleton phylogenetically inherited, and, furthermore, he called attention to the fact that the work of Bernays and later that of Kazzander showed that the patella is neither situated nor developed in the tendon of the quadriceps muscle, but is located quite independent of and behind the tendon. In conclusion, he stated that there is clinical evidence to warrant considerable doubt as to the mechanical value of this bone in movements at the knee joint.

In 1936, twenty cases of partial and total excision of the patella following fracture, in which operations had been performed during the previous four years, were reported by Blodgett and Fairchild. In eight of these patients the entire patella was removed, with excellent results. The remaining individuals in this group were treated by partial excision of the patella, with removal of all of the small fragments. Shorter convalescence and earlier return to function by excision of small patellar fragments after fracture were likewise emphasized by Thomson in 1935.

Berkheiser has recently described excision of the patella in arthritis of the knee joint in eleven patients. There were four cases of atrophic arthritis, two of gonorrhoeal arthritis, and, of the remaining five cases, two were classified as traumatic arthritis. Satisfactory results are reported in eight cases, but the author adds that the fair results in the other three patients were because of poor selection.

In the group of patients here reported, no patient with a preoperative diagnosis of rheumatoid arthritis is included, as we have not found extensive surgery a helpful procedure in this type of arthritic involvement.

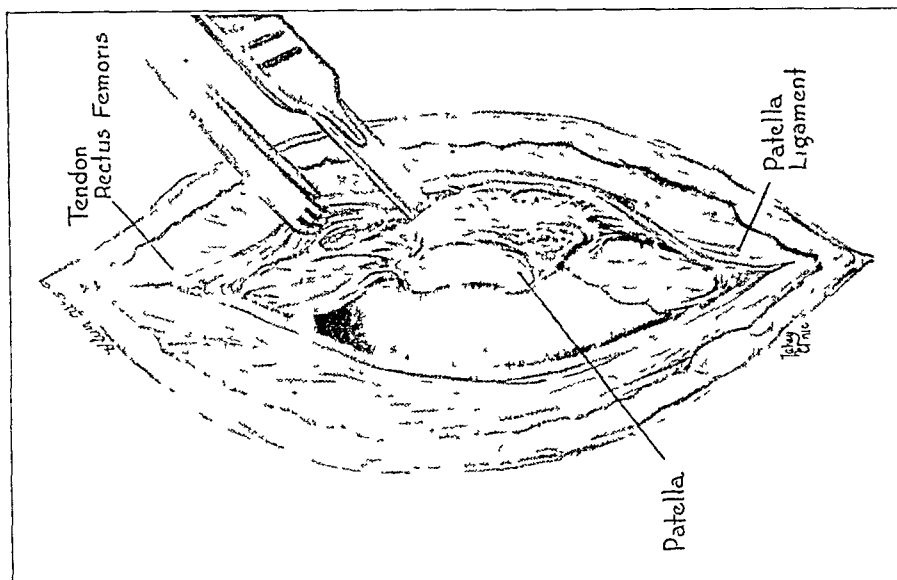


FIG. 3-B

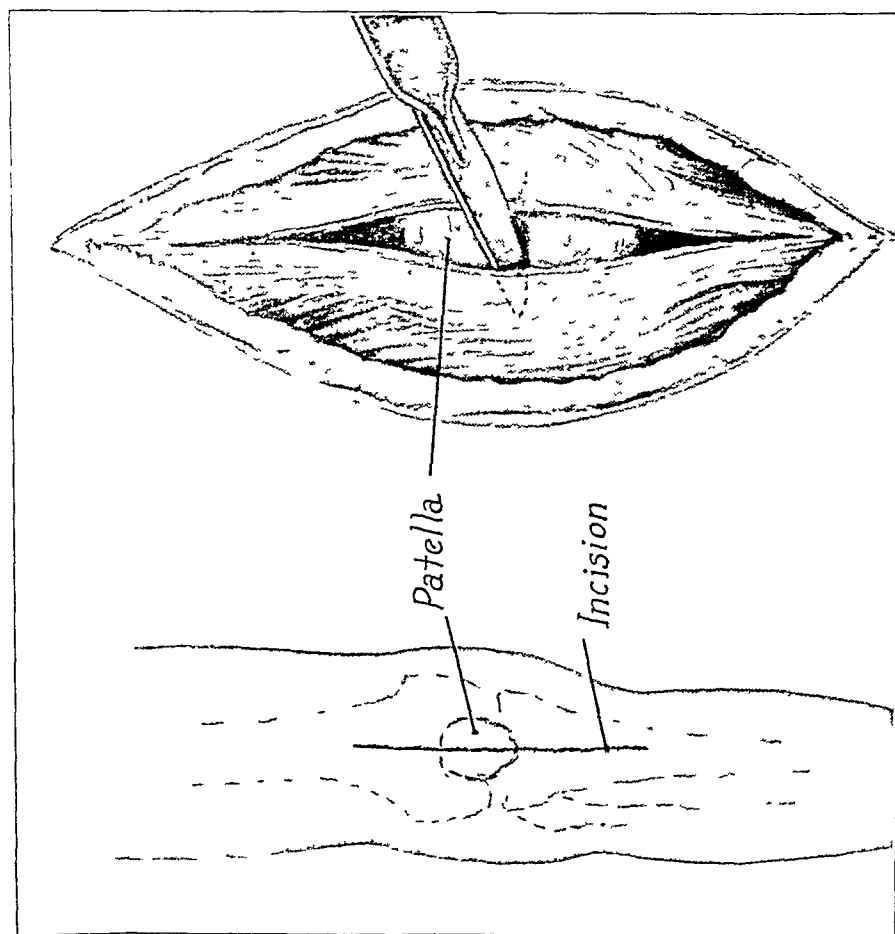


FIG. 3-A

The mid-line exposure, splitting the quadriceps tendon and patellar ligament. Note that the patella lies *behind* and not in the tendon.

In addition to removal of the patella, we also carried out synovectomy, removal of exostoses, and the shaving down of fibrillated and degenerated articular cartilage; in other words, we have removed all abnormalities in so far as feasible. This type of operation has been extensively performed by Magnuson in a large series of cases, with excellent results.

#### OPERATIVE TECHNIQUE

Figure 2 illustrates the median parapatellar incision which has been utilized in nineteen of our cases; in one instance the knee was opened by a curved transverse incision at the inferior margin of the patella. The proximal end of the incision extends well up into the medial aspect of the tendon of the quadriceps, so that it is relatively easy to rotate the patella laterally and thus to allow for its removal. This approach was originally employed as the most satisfactory utility incision for adequate exposure of the knee joint. In this connection the author has been informed by John Adams that a split-patellar incision works as well as, if not better than, the one described. In patients more recently operated upon but not included in this report, the joint was visualized through a vertical incision centered over the patella, and the latter bone was removed by sharp dissection (Figs. 3-A and 3-B).

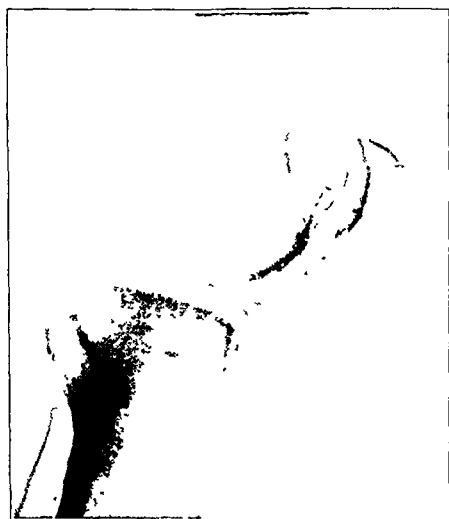


FIG. 4-A

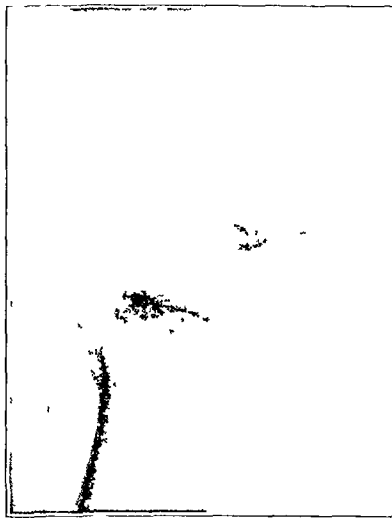


FIG. 4-B

Fig. 4-A: Case 1. Preoperative roentgenogram.

Fig. 4-B: Lateral roentgenogram five years after operation. The extensive degenerative changes evidenced in the preoperative film are not visible after surgery. The patella is reduced in size. There are no symptoms and motion is normal.

In the first patient treated by this procedure the hyperplastic patella was cut down to a thin wafer of bone (Figs. 4-A and 4-B), and its articular surface was covered with fascia. Subsequently this latter step was omitted with no apparent ill effects, and finally the patella was excised.

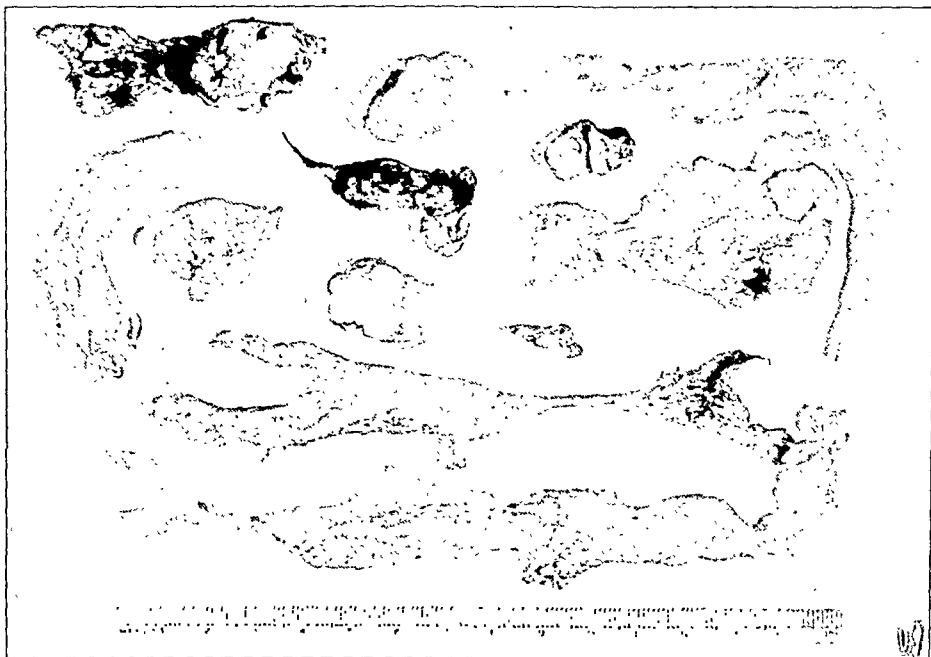


FIG. 5

Case 1. Photograph of degenerated cartilage, menisci, loose bodies, exostoses, and hyperplastic synovial membrane removed at operation.



FIG. 6-A

Case 2. Anteroposterior and lateral roentgenograms in an obese woman of sixty-one years, which show advanced degenerative arthritis, resulting in almost total disability. Note hypertrophy of the patella, which has been displaced to the lateral side. (There was a definite history of recurrent lateral dislocation of the patella.)

Our experience confirms Brooke's statement that the patella is not essential to normal function of the knee joint.

Hyperplastic synovial membrane was removed from the knee joint with the exception of the posterior compartment, including the fat pad, as well as one or both of the menisci, if these latter structures appeared damaged. Exostoses and productive bone changes along the articular margin were cut away (Fig. 5). The capsule was closed with interrupted silk stitches; the subcutaneous tissue, with interrupted plain gut; and the skin, with interrupted silk. In the majority of patients a long leg cast was then applied, following the postoperative dressings, which included a large, fluffy, cotton pad about the knee. When employed, the cast was removed in from five to seven days.

#### POSTOPERATIVE COURSE

After removal of the cast, the patient again resumed muscle exercises, together with intensive local heat to the knee, as well as infra-red light to the leg as a whole and massage of the thigh and of the lower leg.

One of the most effective methods of obtaining early motion in the knees of these patients has been to suspend the extremity at the ankle in a

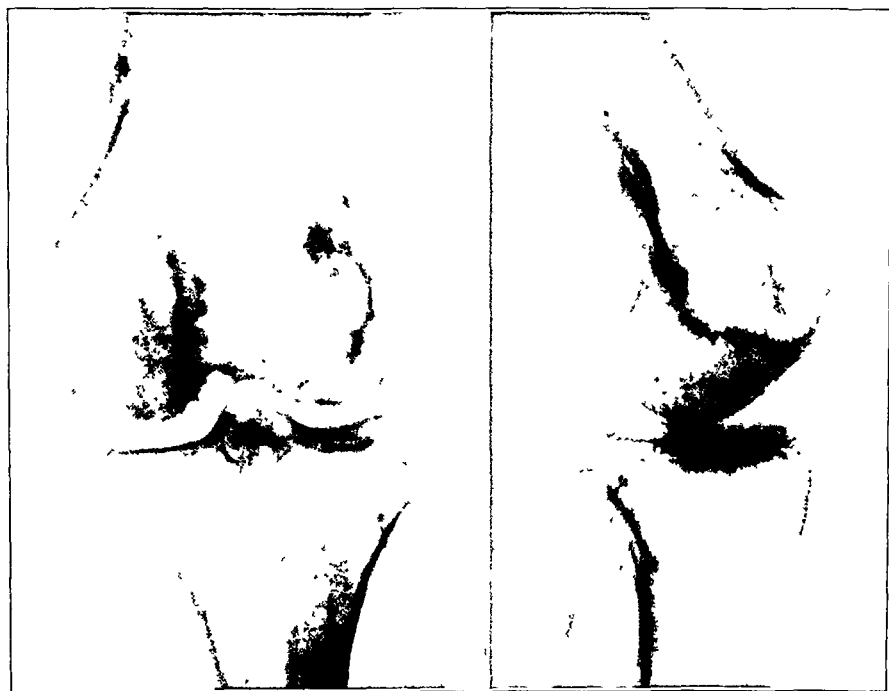


FIG. 6-B

Case 2. Two and one-half years after operation. As compared with Fig. 6-A, there is relatively slight evidence of degenerative change in the knee joint. The destructive reaction in the lateral tibial condyle has been repaired. The patella, of course, is absent. The irregularity of the femoral shaft is the result of a comminuted supracondylar fracture one year previously. This patient now has normal knee function without symptoms.

slings attached to an elastic cord, which, in turn, is fastened to the overhead bar of a Balkan frame, and then progressively to institute bicycle exercises. This is a simple and yet most efficient apparatus, for knowledge of which the author is indebted to Loring Swaim. As soon as adequate muscle strength, particularly of the quadriceps group, was obtained, the patient became ambulatory in progressive stages, walking with crutches. The latter were employed to protect the quadriceps muscle.

With one exception, all operative wounds healed by first intention. That one case was in an extremely obese patient, who exhibited some necrosis of fat tissue at the lower end of the incision. The knee joint was not involved. This area was cleaned up with azochloramide dressings and then was closed with a skin graft. In no instance was it necessary to aspirate the knee postoperatively.

Gentle manipulation of the knee under intravenous pentothal anaesthesia was carried out on all patients within three weeks following operation and before discharge from the hospital. The purpose of this procedure was to break up adhesions which had formed in the joint and to ensure more rapid return of function. There was slight or no reaction in the knee after this manoeuvre, while the range of motion was very rapidly increased.

#### NUMBER OF PATIENTS AND RESULTS

The knee joints of twenty patients have been operated on in the manner described. In each individual only one knee was treated. The average age of this group was fifty-six years. There was one failure, which will be described in some detail. Of the remaining nineteen patients, all are improved, in many instances markedly so, as compared with the preoperative state. The duration of the follow-up ranged from nineteen months to five years; the average length of observation after operation was twenty-eight months.

There was an increase in the range of motion in nineteen patients after operation, as compared to the preoperative joint function. All of this group had normal active extension of the knee. The minimum range of flexion was 75 degrees (15 degrees less than a right angle), while the maximum was normal. Of these nineteen patients, fifteen had a normal range of motion. Each patient had a stable joint, and none exhibited swelling of the knee. Eight patients stated that they had no symptoms referable to the knee joint; six noted that there was some intermittent aching discomfort present in the knee, particularly following exposure to cold or damp weather or after unusual effort. In four patients there was occasional aching pain, especially after a rest period succeeding an interval of pronounced physical activity. One patient complained of painless crepitation on knee-joint motion, which appeared to be the result of proliferative change over the distal anterior femur (Fig. 7-B).

In summary, all nineteen patients stated that they did not suffer severe pain and that they experienced no symptoms comparable to those



FIG. 7-A



FIG. 7-B

Fig. 7-A: Preoperative lateral roentgenogram in a woman, sixty-two years old, showing many loose bodies and marked hyperplasia of the synovial membrane, resulting in pronounced disability.

Fig. 7-B: Nineteen months after operation. There is normal motion of the knee joint with painless crepitation. For cause of proliferative change over the distal anterior aspect of the femur, see text.

present before the operation; all of these patients have returned to their previous occupations.

Of the patients operated upon, with one exception, the follow-up roentgenograms showed essentially no changes when compared with the immediate postoperative films, and in no instance did the follow-up roentgenogram show the extensive degenerative changes revealed in the film taken before operation (Fig. 6-B). The roentgenograms of this one individual exhibited definite proliferation of periosteal bone over the distal anterior aspect of the femur (Figs. 7-A and 7-B). At operation the synovial membrane in this knee joint was excessively hyperplastic, and there was advanced degenerative arthritis. During the postoperative period it was exceedingly difficult to persuade this patient to carry out her exercises, and, because of this fact, manipulation was postponed until five weeks after operation. It is therefore believed that these proliferative changes were the result of injury to the periosteum of the femur following the manipulation, because it was done at such a late date.

One case was a definite failure and warrants a detailed report.

This patient was a minister, fifty-five years of age, who had been seen in the Clinic at intervals during the preceding eleven years, because of an intermittent cyclic synovitis with effusion in the left knee joint of unknown etiology. The roentgenograms revealed early degenerative arthritis. Synovectomy was advised but refused.

Two years before hospitalization this patient began to experience real disability for the first time, due to increasing pain in the left knee. Seven weeks and again two weeks



before admission, the knee had "locked" for several hours. On admission, the patient exhibited a 60-degree flexion deformity with marked atrophy of the musculature of the extremity, together with swelling of the knee region and marked tenderness over the medial joint line. In this same preoperative interval joint discomfort in other parts of the body had begun to develop. Examination before knee arthrotomy did not indicate any significant degree of widespread joint pain, and there were no objective joint changes other than some wrist stiffness with slight swelling.

Preoperative roentgenograms of the involved knee revealed advanced degenerative changes and generalized bone atrophy, as well as marked hyperplasia of the synovial membrane with increased joint fluid. In the hospital the patient received three weeks' preoperative treatment—comprising continued traction to the leg, intensive physiotherapy, muscle training, heat, and massage—to reduce the degree of flexion contracture and to develop muscle power. This was accomplished to the point where there remained a persistent 15-degree knee flexion. It was then felt that following operation the remainder of this contracture could be eliminated.

At operation there was widespread and very marked degeneration of the articular and semilunar cartilages, together with a pronounced hyperplasia of the synovial membrane, including areas of necrosis. Obvious panus formation was evident over the marginal areas of the femoral cartilage, which indicated that we were here dealing with a mixed type of arthritis. This was later confirmed. In the postoperative period the flexion contracture was not completely corrected, and there was pain in the joint on weight-bearing, together with some local swelling. Six months after operation a widespread, clinically typical, rheumatoid arthritis developed. While this patient states that he does not now experience the severe knee pain which was present before operation, and that the joint no longer locks, there still remains a 20-degree flexion deformity, as well as muscle atrophy of the extremity.

This poor result was due to faulty selection, as it was not recognized that we were dealing with a mixed type of arthritis wherein the rheumatoid element predominated.

#### CONCLUSIONS

In patients with pronounced disability from degenerative arthritis of the knee joint, who are selected on the basis of their physical fitness for operation and in particular for their willingness to cooperate with the postoperative regimen herein described, the surgical procedures as detailed in the text result in marked amelioration of symptoms. Over a follow-up period ranging from nineteen months to five years, postoperative observations on a group of twenty patients indicate that the surgical treatment of degenerative arthritis deserves an important part in the physician's armamentarium.

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## INTERPOSITION OF SESAMOIDS IN METACARPO-PHALANGEAL DISLOCATIONS

BY P. DAVID NUTTER, M.D., DETROIT, MICHIGAN

Sesamoid bones are fairly constant at the metacarpophalangeal joint of the thumb and are usually double. They are frequently present at the metacarpophalangeal joints of the index and fifth fingers. Two are often present in the index finger. Occasionally they are found in the third and fourth fingers. These sesamoids are located in the capsular ligament on the palmar aspect of the joint, serving to help strengthen its palmar wall. The concave articular end of the base of the proximal phalanx is very shallow; thus these sesamoids also help to deepen the anterior bony part of the joint.

Several of the various textbooks on fractures and dislocations<sup>1, 2, 3</sup> mention interposition of capsule and sesamoids in metacarpophalangeal dislocations and the obstacles to reduction which they present. In the experience of the Bone and Joint Service of the Receiving Hospital, Detroit, Michigan, it has been found that, with the exception of the thumb, metacarpophalangeal dislocations ordinarily are easy to reduce, but a few cases have required a considerable amount of manipulation, which has taxed the patience, skill, and ingenuity of the operator. These few cases have well earned the reputation of being among the most difficult acute dislocations to reduce which we have encountered.

The following two cases illustrate that interposition of surrounding structures is the greatest factor in making closed reduction difficult and sometimes impossible. This problem was further complicated in Case 1 by the fact that the sesamoid with its detached ligament was pulled over the metacarpal head and its proximal edge was hooked over the dorsum of the distal end of the metacarpal.

CASE 1. S. G., colored, male, aged forty-four, a laborer, on September 16, 1939, came to the Hospital with a history of having fallen from a stepladder, resulting in an injury to the left hand. The patient's description of the way in which this injury was produced was vague and was of no value in accurately determining the mechanism of this type of dislocation. Examination revealed a small skin laceration in the palm of the left hand with deformity of the second and third metacarpophalangeal joints. The hand was greatly swollen, and the patient complained of severe pain, which radiated up the arm to the shoulder.

The laceration in the palm was cleansed thoroughly, and the skin was closed with black-silk sutures without using any anaesthetic. A roentgenogram of the left hand confirmed the clinical diagnosis of posterior dislocation of the second and third metacarpophalangeal joints. A single sesamoid was present at the second metacarpophalangeal joint. The significance of the position of this sesamoid at the time when the roentgenogram was read was not appreciated by the operator.

The patient was given nitrous oxide followed by ether anaesthesia. An attempt was made to reduce the dislocated joints, using manipulation and traction in the usual manner, by first slightly hyperextending the dislocated fingers and pushing downward



Fig. 1-B

Case 1. Roentgenogram after open reduction, showing the sesamoid at the second metacarpophalangeal joint in its normal position.



Fig. 1-A

Case 1. S. G. Roentgenogram before reduction, showing posterior dislocation of the second and third metacarpophalangeal joints with interposition of a single sesamoid at the second metacarpophalangeal joint.

on the bases of the proximal phalanges until the bases came opposite the metacarpal heads and then forcing them over the metacarpal heads into position. This was first tried on both fingers together, then on each one separately. The dislocation of the third metacarpophalangeal joint was reduced after much manipulation, but promptly recurred while the operator was attempting to reduce the dislocation of the other joint. Further attempts were then made to reduce the dislocations by various manoeuvres, but were unsuccessful.

Traction wires were then inserted through the pulp of the distal phalanx of each dislocated finger and were attached by elastic bands to a banjo splint, which held the fingers in 145 degrees of flexion. The traction was increased from day to day and was checked roentgenographically. After a week no change in the relation of the bones was found. The hand remained swollen, but the pain markedly subsided. The lacerations healed by primary intention.

Open reduction was then decided upon, but the skin on the dorsum of the hand was in an unhealthy condition. This was fissured and oedematous, which made any operative procedure inadvisable, because of the risk of infection. The traction angle was then changed from 145 degrees of flexion to 120 degrees of flexion and after a week was checked with another roentgenogram, which showed no improvement in the dislocations. The traction was continued until October 23, 1939, at which time the skin was considered to be healthy enough to make an operative procedure safe. At this time a check-up roentgenogram showed some destructive change in the third metacarpal head.

On October 24, 1939, through a dorsal incision, one and one-fourth inches long, between the heads of the second and third metacarpals, the dislocated joints were exposed. The sesamoid in the palmar capsular ligament of the second metacarpophalangeal joint

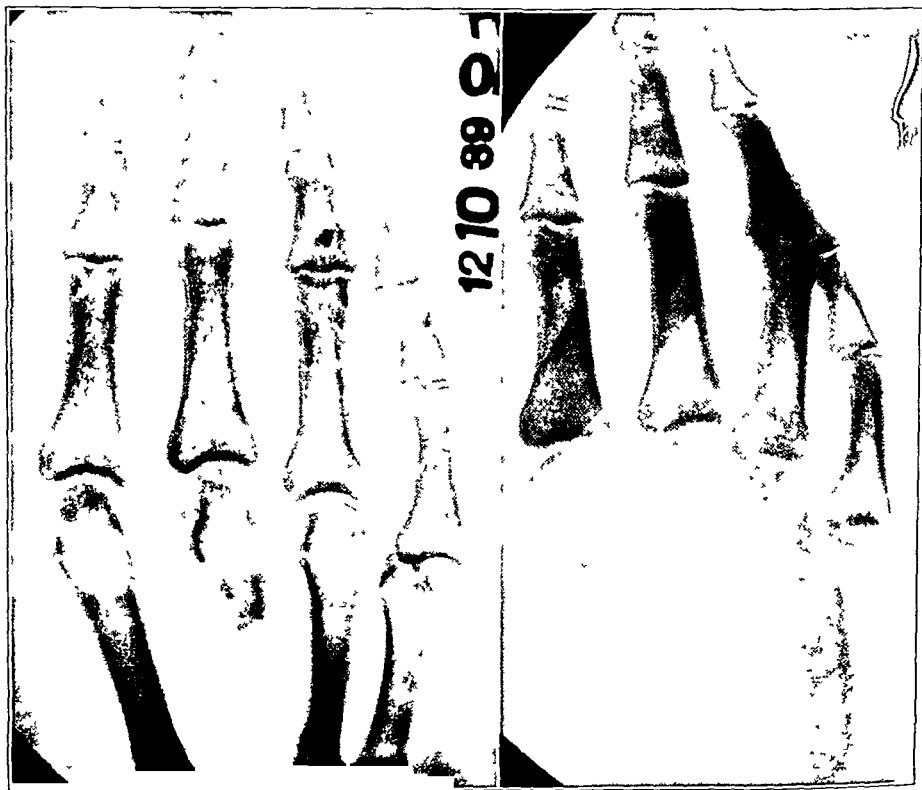


FIG. 2-A

Case 2. J. S. Roentgenograms before reduction, showing a posterior dislocation of the fifth metacarpophalangeal joint with interposition of a single sesamoid.

was found to be pulled through the joint space with its ligament, which was still attached proximally. The proximal edge of the sesamoid was hooked over the dorsum of the head of the metacarpal, while the capsular ligament in which it was embedded was detached from the base of the proximal phalanx and covered the metacarpal head.

The sesamoid was detached from the dorsum of the metacarpal head and replaced in its normal position. By manipulation and traction the dislocation was then easily reduced.

The head of the third metacarpal was found to be quite necrotic and fragmented. At the time of operation this was thought to be due to an aseptic necrosis. The necrotic head was removed, and portions of the joint capsule were found to be interposed between the metacarpal head and the base of the phalanx. This was excised, and the dislocation was reduced in the same manner as the other joint. The wound was then closed by reconstructing each successive layer as well as possible. An anterior molded plaster splint was applied, which held the wrist in dorsiflexion and the fingers in 140 degrees of flexion.

On the second day following operation a bloody discharge was noted on the dressings of the wound. The dressings were removed, and a purulent bloody drainage was found to be oozing from the wound. Sterile, hot, wet magnesium-sulphate compresses were applied locally, and the following day all skin sutures were removed. Roentgenographic examination showed evidence of further destruction of the third metacarpal, and a diagnosis of osteomyelitis was made. Hot compresses were continued for two weeks longer, and the discharge gradually subsided. The wound quickly healed by filling up from the bottom with granulation tissue.

Active exercises were begun ten days following operation, and, when the wound had completely healed, daily baking and massage were added. The patient was discharged from the Hospital on November 18, 1939. He returned to the Physiotherapy Department three times a week for baking and massage and exercises of the hand for a period of three weeks following his discharge. At the end of this time, examination showed that the patient had full active extension of both injured fingers and flexion of each finger to 108 degrees.

CASE 2. J. S., white, male, aged twenty-nine, a laborer, came to the Hospital on December 9, 1939, with a history of having fallen, striking the palm of the right hand and



FIG. 2-B

Case 2. Roentgenogram after reduction, showing the sesamoid in its normal position.

the fingers on a curb. Examination revealed a posterior dislocation of the fifth metacarpophalangeal joint with a considerable amount of swelling. Roentgenographic examination confirmed the physical findings and also showed the presence of a single interposed sesamoid bone.

The patient was given nitrous oxide, followed by ether anaesthesia, and an attempt was made to reduce the dislocation by the usual method of hyperextension, traction, and flexion, but this was unsuccessful. The dislocated finger was then manipulated by maintaining moderate traction and at the same time rotating the dislocated phalanx first medialward and then lateralward several times. The sesamoid was felt to slip anteriorly into place, and the dislocation was then easily reduced in the usual way. A check-up roentgenogram showed a reduction of the dislocation with the sesamoid in its normal position.

A posterior molded plaster splint was applied, holding the fourth and fifth fingers in 90 degrees of flexion. This was removed at the end of two weeks, and light exercises were begun. A check-up examination, two weeks after removal of the plaster splint, showed that the patient had a full range of painless active motion in the injured joint.

#### CONCLUSIONS

1. Interposition of sesamoids in metacarpophalangeal dislocations frequently adds to the difficulty of reduction of these dislocations.

2. When the interposition of sesamoids is present an attempt should first be made to replace these bones in their normal positions by moderate traction on the fingers and rotation of the phalanges medialward to lateralward several times before reduction of the dislocations is tried.

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## SPONTANEOUS HEMARTHROSIS DUE TO SYNOVIAL GRANULOMA

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In the absence of definite inflammatory disease, spontaneous swelling of a joint is an unusual and startling symptom. The so-called intermittent hydro-arthritis, characterized by the periodic sudden development and subsequent absorption of an effusion, has in many instances a definite etiological factor. Often, however, the cause is obscure, although the condition is considered by many to be an allergic manifestation. Fortunately, when an effusion contains blood and no injury has immediately preceded the onset, the differential diagnosis narrows down to two groups of lesions: (1) blood dyscrasias, such as hemophilia, leukaemia, purpura, and the like; and (2) tumors. The synovial cavity does not differ from other serous cavities in that the aspiration of a bloody fluid, in the absence of injury or blood dyscrasia, points to the presence of a tumor, the surface of which has been eroded. In most instances of spontaneous hemorrhage into a joint, the blood will provoke an effusion, and the admixture has a consistency and appearance which immediately distinguishes it from pure blood. However, if a cavernous hemangioma involves the synovial cavity, it is possible to aspirate pure blood from one of the tumor spaces. Such a finding is usually pathognomonic.

Tumors arising from synovial membrane are rare, but, when found, they involve the knee more frequently than any other joint. This fact is borne out by the several small series available in the literature. Commonly these tumors are benign—xanthomata and hemangiomata—but of the primary malignant group the synovioma is most frequently mentioned. This is an ill-defined growth, the classification of which is controversial. Sarcoid tumors, fibrosarcoma, mixed-cell sarcoma, myeloid sarcoma, and myeloplaxoma are other names used to designate malignant growths thought to be primary in synovial tissues. The tumor in the following case is considered worthy of a report because: (1) despite its simple and benign nature, it was capable of producing recurrent spontaneous bleeding into a joint cavity,—a feature usually reserved for lesions of a more serious nature; (2) although the rôle of trauma in its production seems well established, its subsequent growth and clinical course take it out of the category of the ordinary synovial impingement, which may cause transient symptoms following trivial injuries; and (3) a discussion of synovial granuloma is not available in the literature.



## CASE REPORT

C. C., a white male, twenty-four years old, was admitted to Passavant Memorial Hospital on April 18, 1939. He stated that on September 2, 1938, he had struck his right knee against the dashboard of his car. Although the skin was unbroken, slight generalized swelling and tenderness followed, but subsided in two or three days. Two months later (November 1938), while walking, the knee began to swell for no apparent reason. The swelling attained such proportions and became so painful that two aspirations were necessary to relieve the tension. Each time about fifty cubic centimeters of synovial fluid was withdrawn. A light cast was applied, and, at the end of ten days, the knee appeared normal. The patient did not complain of pain, but some quadriceps weakness was

present. A few days after the removal of the cast, while the patient was walking with the aid of a cane, the swelling and pain recurred, and aspiration was again necessary. This time about thirty cubic centimeters of bloody synovial fluid was removed. At the end of two weeks the patient returned to his work, complaining only of weakness of the knee, which was explained by the increasing atrophy of the thigh. In April 1939, seven months after the injury, and five months after the appearance of the first effusion, all symptoms had subsided and the patient was in no way disabled, when, while walking, he suffered another recurrence of the entire syndrome. Aspiration this time produced fifty cubic centimeters of a frankly bloody synovial fluid. Roentgenographic studies of the knee continued to be negative, and, after removal of the fluid,

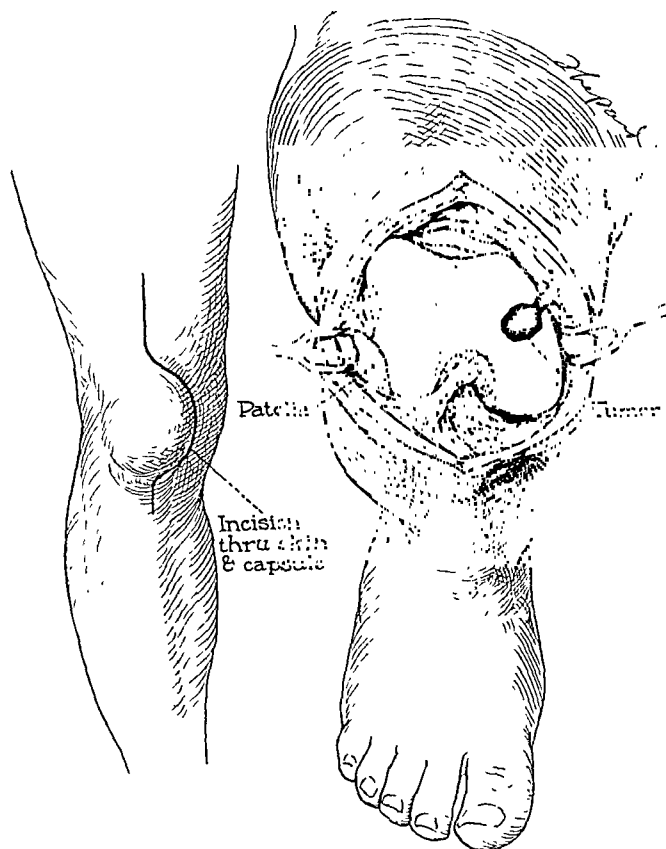


FIG. 1

Median parapatellar incision used. With the patella reflected laterally and the knee flexed, the location, shape, and relative size of the tumor and its pedicle are seen.

no masses, localized tenderness, or abnormal motion could be found. The history, aside from this specific complaint, was negative, as was the general physical examination. Blood and urine studies revealed nothing of importance, and a smear and culture of the aspirated fluid were not helpful in establishing a diagnosis.

The patient finally consented to an exploration of the knee, and a preoperative diagnosis of synovial tumor—probably a small hemangioma—was made. On April 19, 1939, the knee was operated upon. When the joint was opened, the synovial membrane was found to be somewhat oedematous, and it had the icteric tint usually found after hemorrhage. On the medial surface of the synovia at the level of the femoral condyles the tumor was seen (Fig. 1). It was liver red in color, solid in consistency, the size and shape of an almond, and freely movable on the half-inch pedicle to which it was attached. Slight erosion of the patellar and medial condylar cartilages attested to the fact that



FIG. 2

Representative section showing areas of recent hemorrhage, fibroblasts, inflammatory cells, and capillaries of various sizes. Rather than specific tissue, the sections reveal a definite, though constantly thwarted, attempt at repair. (Photomicrograph  $\times 60$ .) *Inset*: The gross appearance.

intermittent impingement of the tumor between these joint surfaces caused the recurrent hemorrhage. The tumor was excised, and an area of normal synovia, about the size of a half dollar, surrounding the base of the pedicle was included. Microscopically the mass was found to be granulomatous in nature. Numerous inflammatory cells, fibroblasts, and capillary blood vessels of various sizes were the essential features of the picture (Fig. 2).

Convalescence was uneventful, and, at the end of six weeks, the patient returned to his duties as a salesman. He has had no complaints since that time.

## LOCALIZED VOLKMANN'S CONTRACTURE

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The typical contracture of the forearm which was first described by Richard Volkmann of Halle at the end of the last century is generally a sequela of a serious injury in the neighborhood of the elbow. Its exact explanation is still, to some extent, a matter for conjecture, but it is now generally recognized that direct trauma to the muscle tissues of the forearm may give rise to a deformity similar to that found in association with supracondylar fracture of the forearm. The author has previously observed a case of extensive contracture, following a crushing injury of the forearm, which was not associated with fracture; and during the last few months he has been treating a localized contracture of a single finger, which has many features in common with the more serious case. The report of this latter case follows.

A typist, aged twenty-five, was struck on the front of the mid-forearm by a tennis ball. The blow was rather severe, and the patient suffered considerable pain. Swelling followed almost immediately, and, in a day or two, there was a fair amount of bruising and of discoloration over the front of the forearm. The flexion movements of the fingers were limited and painful. The author did not see the patient at this stage, but, three or four weeks after the original injury, she presented herself at the Out-Patient Clinic of Edinburgh Royal Infirmary with the complaint that she was unable to straighten the middle finger, which had gradually become deformed after the accident.

The condition on examination is shown in Figure 1. There was a flexion contracture of the finger, involving the metacarpophalangeal and the proximal interphalangeal joints.

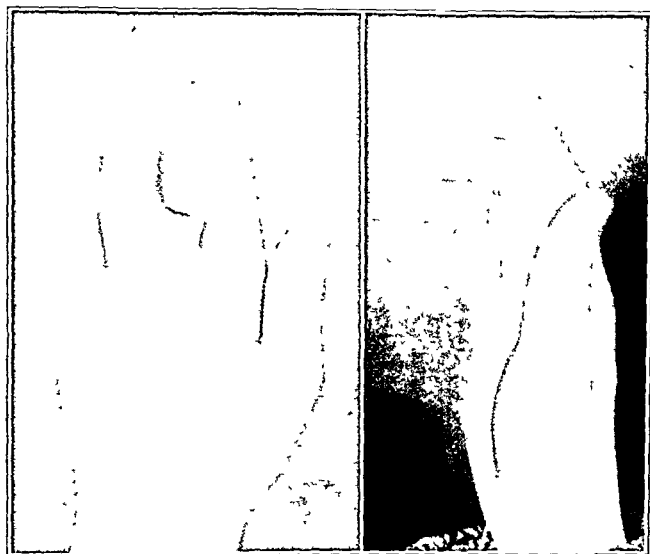


FIG. 1  
Condition before operation.

The deformity was obvious with the wrist in the neutral position, but was greatly accentuated by dorsiflexion of the wrist. On the other hand, the finger became straight when the wrist was fully palmar flexed. Palpation of the forearm, when the wrist was extended, revealed a very tightly contracted tendon immediately above the wrist. This could be traced upward to an indurated area about the middle of the forearm, and the diagnosis was obviously one of contracture of the flexor digitorum sublimis fibers to the middle finger.

The deformity was seriously interfering with the patient's work as a typist, and, since the lesion was so localized, an operation was advised. The affected tendon was exposed through a short incision immediately above the transverse carpal ligament, and a lengthening operation was carried out by the sliding method. The deformity was completely corrected, and the tendon fragments were then sutured with waxed silk. A plaster-of-Paris case was applied to maintain the wrist and the middle finger in an extended position.

The plaster case was retained for a period of six weeks, and subsequently massage and movements were employed. The result is shown in Figure 2. There has been virtually complete restoration, both of appearance and of function.

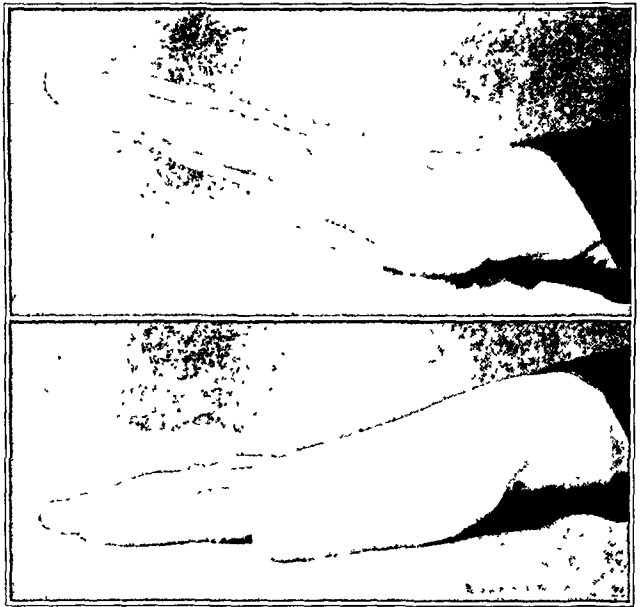


FIG. 2

Showing restoration of function.

This type of case is possibly not rare. The author personally has not encountered a similar one, nor has he come across a report of one in the literature. It would appear that the original injury provoked a hemorrhage into and among the muscle fibers destined to join the flexor digitorum sublimis tendon of the middle finger; and that fibrosis resulted, probably in association with destruction of the muscle tissues.

It seems to indicate that "Volkmann's contracture" includes several distinct entities, the common features being death of the muscle tissues and replacement fibrosis. Obstruction to the venous return from the muscle and arterial deprivation (ischaemia) are the most often quoted causes of the muscle destruction, which is in consequence believed to be anoxaemic. In the case reported here, it is possible that the fibers were actually disrupted by the original injury; it is, however, also possible that the hemorrhage, by increasing the tension within the muscle sheath, created vascular obstruction and anoxaemic degeneration of the muscle fibers, as in the ordinary case of Volkmann's contracture.

# A CASE OF SO-CALLED "OPEN-BEAK" FRACTURE OF THE OS CALCIS

BY JOHN O. DIETERLE, M.D., MILWAUKEE, WISCONSIN

The patient, a domestic, aged fifty, while kneeling with the foot resting on the ball in the vertical position, was struck over the back of the heel by the edge of a falling step-ladder. There was immediate disability with considerable ecchymosis and swelling and later bleb formation about the heel. Immediate reduction could not be done on this account (Fig. 1).



FIG. 1



FIG. 2

After one week, when the skin had healed, an unsuccessful attempt was made to reduce the fracture by pressure on the fragment with the foot in the position of plantar flexion. A mid-line incision, centered over the hiatus in the heel, was made after splitting the Achilles tendon, and the fracture was reduced and the fragment sutured with heavy chromic gut (Fig. 2).

Weight-bearing was allowed after eight weeks' disability, when the fragment had united.

This fracture is quite rare and, as stated by Böhler, presents no difficulty in reduction. The tubercle of the os calcis is not pulled upward by the Achilles tendon, but is split off and held in the position as shown by impingement of the sharp edge of the fragment against the Achilles tendon. With the foot in the plantar-flexed position, reduction by manipulation should be easy, provided there are no complications such as occurred in the case reported.

# ISOLATED TUBERCULOSIS OF THE SPINOUS PROCESS OF A VERTEBRA

## REPORT OF A CASE

BY RANDOLPH L. ANDERSON, M.D., F.A.C.S., CHARLESTON, WEST VIRGINIA

As is well known, the anterior portion of the vertebral body is the part usually involved, and at times the disease spreads to the pedicles and the laminae, but rarely affects the spinous processes. Therefore, it is felt that the following case of isolated tuberculosis of the spinous process of the fourth lumbar vertebra may be of interest.

J. B., male, aged twenty-three years, a student, while jumping up as he led the cheering at a basketball game on February 13, 1929, felt something give in his back. He walked to his room with difficulty. He was seen by the author two days later, and was admitted to the Johnston-Willis Hospital in Richmond, Virginia. There was acute tenderness over the fifth lumbar vertebra, and intense spasm of the erector spinae muscle. Roentgenographic examination of the lumbar spine was essentially negative. A plaster jacket was applied under general anaesthesia, and after one week the patient returned to school.

He was readmitted to the Hospital on March 8, 1929, because of pain in the lower back. After a stay of three days he went home, where he remained in bed until May 1929. After getting up, he was comfortable, and, in September 1929, a sacro-iliac belt was applied.

On October 7, 1929, abdominal pain and fever, with a temperature of 103 degrees, developed, and the patient remained in another hospital for a week, but no definite diagnosis was made. He reported no back symptoms at that time.

When he was seen during the latter part of October 1929, clinical examination of the back was negative, but he had lost several pounds in weight. Roentgenographic examination of the chest and sputum analysis showed no evidence of pulmonary tuberculosis. In February 1930, roentgenographic examination of the spine was repeated with negative results.

During the latter part of April 1930, the patient noticed a small lump on the lower back, which rapidly grew larger. When seen about ten days later, there was a fluctuant mass over the lower lumbar spine, approximately two and one-half inches in diameter, which was slightly reddened, but not especially tender. There was no muscle spasm or limitation of motion in the lumbar region. The temperature was 99.8 degrees. Approximately 100 cubic centimeters of thin, yellowish fluid was aspirated from the mass, and again roentgenograms of the lumbar spine were taken. These disclosed osteomyelitis of the spinous process of the fourth lumbar vertebra, probably of tuberculous origin. The mass was aspirated a number of times at weekly intervals. The fluid showed no growth on culture. The Wassermann reaction was negative. The hemoglobin was 85, and the white blood count was 17,000 with 72 per cent. of polymorphonuclear leukocytes. A Mantoux intradermal tuberculin test in the dilution of 1 to 7500 was positive. Roentgenographic examination of the chest showed no active tuberculosis.

On June 13, 1930, an operation was performed. A longitudinal incision was made over the lower lumbar spine. About one-half of the spinous process of the fourth lumbar vertebra was found to be softened and replaced by granulation tissue. A definite walled-off area of granulation tissue, at least two inches in diameter, surrounded this diseased process. The affected spinous process was removed with rongeurs well back into healthy bone tissue, and the wound was sutured loosely. A thin, serosanguineous fluid



FIG. 1

J. B. Roentgenogram on February 29, 1932, showing postoperative defect in the spinous process of the fourth lumbar vertebra.

intervals until the latter part of 1932, and then ceased. Repeated roentgenographic examinations later failed to show any further extension of the process. The patient was last seen in January 1939, and was entirely well.

A thorough search of the literature has been made, and it has been found that twelve cases in which the spinous process of the vertebra alone has been involved in tuberculosis of the spine have been reported in the foreign literature. No cases have been recorded in the American literature.

Lannelongue, in 1878, was the first author to report such a case, and later he described two more. Other cases have been reported by the following: Polaillon, two cases; Coyola, three cases; Therme, two cases; Perrenot, one case; and Boeckel, one case.

The location of the lesions was as follows:

Site	No. of Cases
Cervical vertebra . . . . .	1
Thoracic vertebra . . . . .	5
Lumbar vertebra . . . . .	3
More than one . . . . .	2
Not described . . . . .	1

drained from the wound throughout the patient's stay in the Hospital, during which his temperature ranged between 99 and 101.5 degrees. He was discharged on July 3, 1930, with instructions to remain in bed and to take daily sun baths. He remained in bed constantly for two months.

Microscopic examination of the tissue removed at operation showed giant-cell formation typical of tuberculosis, and granulation tissue removed from the wound and injected into a guinea-pig caused the development of tuberculosis in its liver and spleen.

In September 1930, three months after operation, the patient was free from symptoms, except for slight drainage through the operative scar, and had gained in weight. Roentgenographic examination of the spine at this time showed no further evidence of tuberculosis.

Drainage kept up at

intervals until the latter part of 1932, and then ceased. Repeated roentgenographic examinations later failed to show any further extension of the process. The patient was last seen in January 1939, and was entirely well.

A single vertebra was involved in seven cases, and two vertebrae were involved in five cases.

Five other cases of involvement of the spinous process, combined with lesions of other portions of the posterior parts of the arch of the vertebra,—that is, the transverse processes, the laminae, or the articular processes—were reported.

It is interesting to note that only thirty new cases were found in which the posterior portion of the vertebra alone was affected with no involvement of the body.

A brief historical summary of tuberculosis of the posterior portion of a vertebra may be of interest.

Plater, in 1614, reported a case in which what he described as a spinous process of a vertebra was discharged from an abscess, which healed.

F. Ribes, in 1821, spoke of the localization of the tuberculous involvement in a spinous process.

J. Bouillaud, in 1828, gave the first detailed description of tuberculosis of the posterior portion of a vertebra.

Heine, in 1834, was the first to operate on a tuberculous spinous process.

Lannelongue, in 1888, was the first to write a treatise on tuberculosis of the posterior portion of a vertebra.

The first symptom of tuberculosis of the spinous process of a vertebra is pain, and this is followed after a variable period by an abscess. Often there is no muscle spasm. The diagnosis is made from the presence of pain and an abscess, a positive Mantoux test, and the roentgenographic findings. No gibbus or paraplegia is present when this process alone is involved. These lesions are less common and less grave than lesions of the bodies of the vertebrae.

This type of tuberculosis is relatively more frequent in adults than in children.

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# A USEFUL MODIFICATION OF RUSSELL TRACTION

BY EDWARD T. CROSSAN, M.D., AND LAWRENCE E. GRIFFIN, M.D.,  
PHILADELPHIA, PENNSYLVANIA

*From the Episcopal Hospital, Philadelphia*

There can be little dispute about the efficiency of Russell traction in the treatment of fractures of the shaft of the femur. Our experience with the method has been entirely satisfactory, except in treating fractures of the lower fourth of the shaft. In nearly all fractures of this type there is a posterior displacement of the lower fragment, due to muscle pull. In these injuries we have not had any success with the Russell traction, nor, as a matter of fact, have we been able to secure closed reduction by any method until one of us (L.E.G.) devised the modification to be described.

With the Russell traction we have tried the method of sliding the canvas sling from the position under the knee to a place beneath the displaced lower fragment. Our results with the shift have been entirely fruitless. As a matter of fact, it is doubtful if the shifting would work often, because, when an upward pull is made directly on the lower fragment, the force is transmitted to the upper fragment; consequently the relative positions of the fragments remain unchanged. It is certainly true that the shifting of the sling changes the resultant traction force and, judging from results, not for the better.

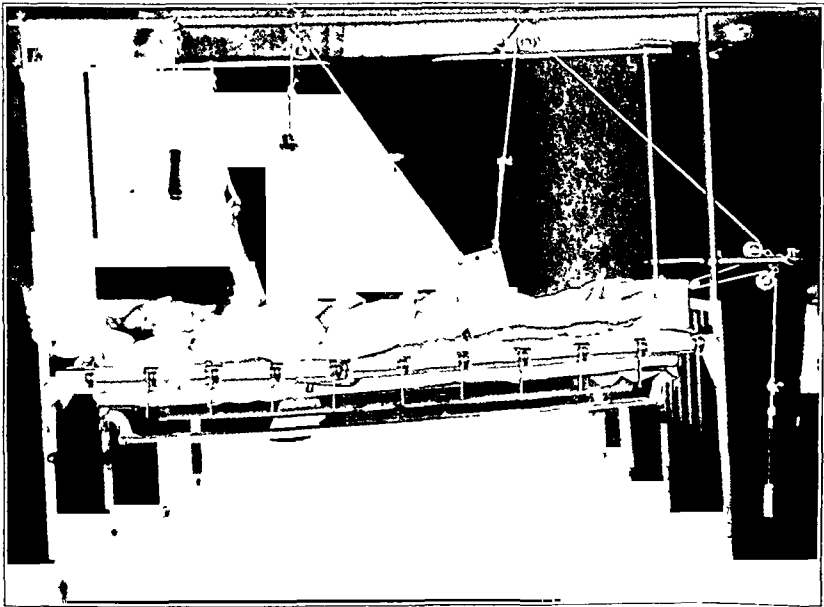


FIG. 1  
Modification of Russell traction.

In the modification herein advocated there is no change in the sling. In this method the attempt is made to secure the traction in the line of the femur, as advocated by Russell, and, in addition, to effect a dorsal tilting of the lower fragment by applying to the upper end of the sling under the knee a force which pulls upward and slightly cephalad.

This sling has three equidistant holes on each short side. When the sling is passed beneath the knee and the short ends are apposed above the knee, a loop of rope is passed through the middle holes and the holes toward the foot, and to this loop is attached the line composing the Russell traction. To the upper holes—those toward the head—is fastened a rope which passes upward and toward the head of the bed and is attached through a pulley to a four-pound weight (Fig. 1). Or, expressed in another way, a pulley is placed in the overhead frame at a point somewhere near the mid-point between the knee and the hip, and through this pulley is passed a rope, which is attached at one end to the upper holes of the sling and at the other end to a four-pound weight.

It should be stated that this modification has one disadvantage. The extra force to the sling causes the upper end of the sling to cut into the posterior aspect of the thigh just above the popliteal space. To prevent pressure sores we have found it necessary to use sponge rubber between the skin and the sling.



FIG. 2-A

Case 1. May 25, 1939.



FIG. 2-B

Case 1. May 31, 1939.

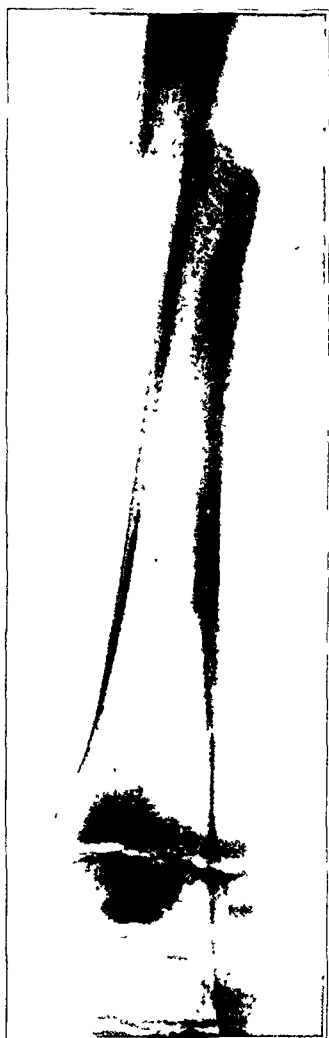


FIG. 3-A

Case 2. October 7, 1939.

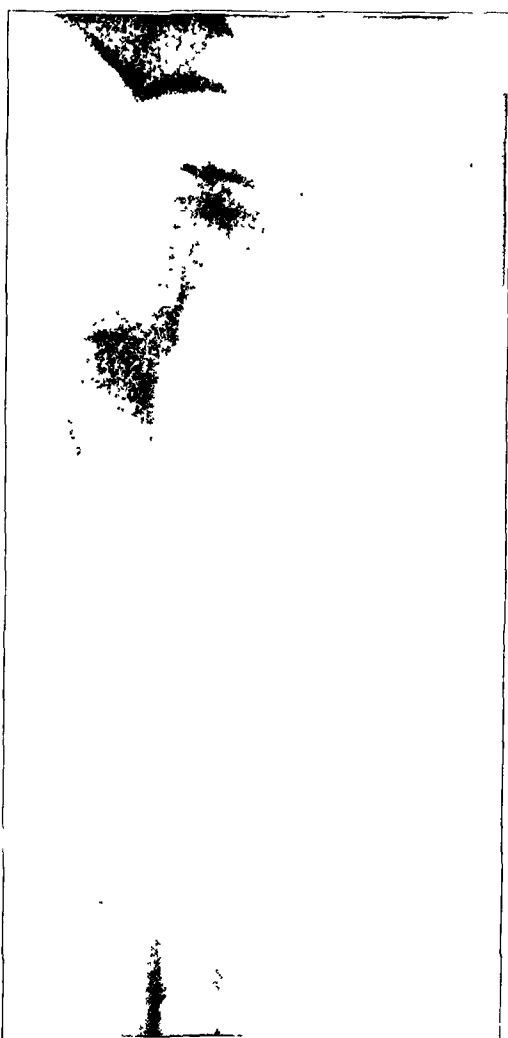


FIG. 3-B

Case 2. October 10, 1939.

We have used this modified Russell traction in the following two cases.

CASE 1. G. G., male, twenty-four years old, while running, struck a fireplug, sustaining an injury to the right lower extremity. The previous medical and family histories were negative. With the exception of the local condition of the right lower extremity, the physical examination was negative.

In the right lower extremity there was marked swelling of the lower part of the thigh. Crepitus and shortening were noted in the lower fourth of the thigh. The first roentgenographic examination (Fig. 2-A) showed a comminuted fracture, involving the lower and middle thirds of the femur with marked posterior and medial displacement of the lower fragment. Six days after admission to the Hospital, and after the application of the modified Russell traction, the roentgenogram (Fig. 2-B) showed the fragments in end-to-end apposition, and indicated that there was a slight amount of overpull.

The patient made an uninterrupted recovery and was discharged from the Hospital nine weeks after admission, without deformity.

CASE 2. A child, six years old, was admitted to the Hospital on October 6, 1939, with a fracture of the right femur after having been struck by an automobile. Although the fracture was higher than the lower fourth, the posterior displacement could not be corrected. Examination showed a marked degree of swelling and discoloration in the lower third of the right thigh, and crepitus and shortening were present. Roentgenographic examination (Fig. 3-A) showed a fracture involving the shaft of the femur at the junction of its middle and upper thirds with moderate posterior displacement of the lower fragment. The roentgenogram (Fig. 3-B) taken three days after admission and following the application of the modified Russell traction showed end-to-end apposition.

In this case, through error, the traction apparatus was removed a few weeks after its application, and following this there was a recurrence of the deformity.

Our purpose in offering this report is to invite other surgeons to give the method a trial. Since our experience embraces only two cases, we are apologetic about rushing into print. On the other hand, several years may pass before we shall have enough cases to prove the point.

## REPORT OF A CASE IN WHICH A VITALLIUM PLATE COULD NOT BE REMOVED

BY EUGENE W. SECORD, M.D., AND LOUIS W. BRECK, M.D., EL PASO, TEXAS

We believe that the following experience with a vitallium plate will be of interest to all who are using this material. To the best of our knowledge it is the first case of its kind to be reported in the literature.

### CASE REPORT

On December 10, 1938, a white male, twenty-two years old, sustained a fracture of both bones of the right forearm near the middle. A closed reduction was attempted, but was unsuccessful. Therefore, on December 28, 1938, an open reduction was done. The radial fragments were approximated and fixed by means of a vitallium plate and screws. The ulnar fragments were fixed together with one piece of stainless-steel wire, and a plaster cast was applied. Convalescence was uneventful.

On March 2, 1939, a roentgenogram showed a large amount of callus at the sites of both fractures and no reaction around the plate or screws. The patient was advised to have the plate removed in a month.

On September 22, 1939, this patient returned for reexamination, stating that he had been out of town for the previous seven months. He had no complaints, and the function of the arm was normal. Roentgenograms showed reestablishment of the trabeculae and the medullary canals and no evidence of absorption around the plate or screws.

On September 28, 1939, a second operation was performed with the intention of removing the plate. There was a minimum of scar tissue overlying the plate, and, covering its distal end, there was a layer of bone, about one and five-tenths millimeters long by three millimeters thick; elsewhere the edges of the plate were overlapped with flakes of bone. Several vigorous attempts were made to remove the screws. Finally, one of us fitted the end of a screw driver into the slot of a screw while the other grasped the shaft of the screw driver with a pair of pliers, and simultaneously we exerted a twisting motion. Despite our combined efforts, we were able to loosen only one of the four screws. The plate and screws were all left *in situ*.

### CONCLUSIONS

This experience presents additional evidence of the non-irritating nature of vitallium. We believe that until there is evidence to the contrary, these plates should be left in indefinitely.

# KIRSCHNER WIRES COMBINED WITH PLASTER CASTS IN FRACTURE TREATMENT

BY GORDON MONROE MORRISON, M.D., SAN MATEO, CALIFORNIA

*From the Community Hospital,\* San Mateo*

The purpose of this paper is to describe a simple and effective technique for combining Kirschner wires with plaster casts. An inexpensive and efficient wire-tightening tool is made by welding a set-screw clamp to one of the jaws of a valve lifter.† Small set-screw-clamp plates complete the apparatus (Fig. 1).

A Kirschner wire is driven through the limb. The area above and below the wire for about two inches is encircled with a carefully molded, fast-setting plaster collar about three-eighths of an inch thick. The plaster is allowed to harden, and a set-screw clamp is fastened against the collar on one side. On the other side a clamp is slipped over the wire, but is not tightened until the wire is stretched and the loose clamp is forced against the plaster with the valve-lifting tool. The clamp thus held in position is fastened, and the tool is removed. The plaster collar

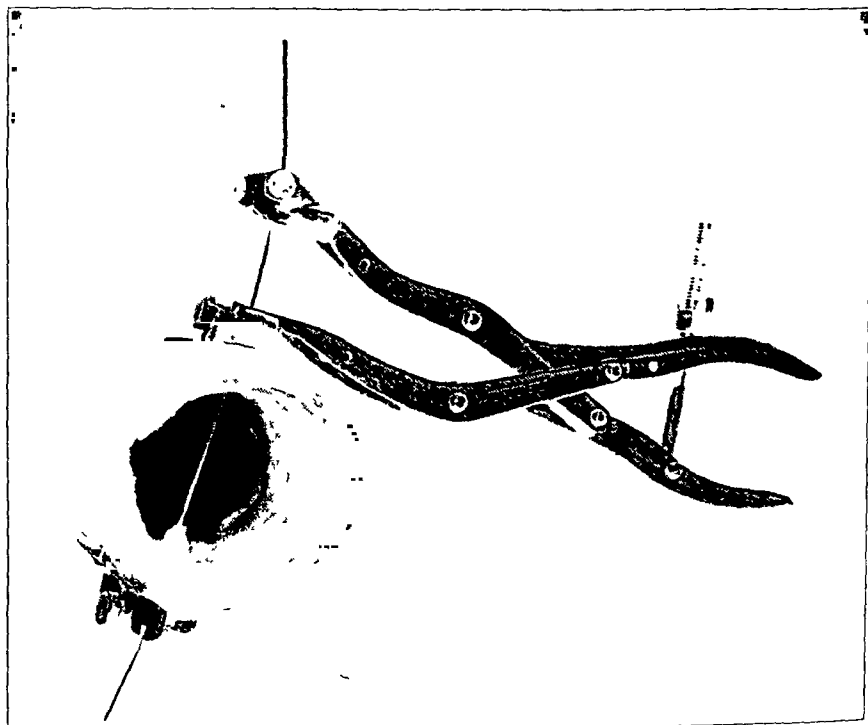


FIG. 1

Converted valve lifter, section of plaster cast, clamps, and wire, showing method of tightening wire.

\* Fracture Service of E. W. Cleary, M.D.

† Valve-lifting tool available at automobile-parts stores.

is thereby used as a stirrup, and the wire is taut with relation to the plaster. There is no danger of crushing the plaster, if reasonable care is used.

Collars and transfixion wires are placed above and below the fracture. The fracture is reduced by traction, and the reduction is maintained by filling in the space between the collars with a plaster cast. Any desirable change in position can be easily effected by wedging the cast.

Traction necessary for the reduction of fractures of the tibia and the fibula can be easily obtained manually while an assistant completes the cast between the two collars. Manual rather than mechanical traction in these particular fractures is good insurance against distraction and its attendant hazards.

Femoral-shaft fractures are reduced by mechanical traction on the Hawley table or similar apparatus, using a temporary sling about the ankle with perineal-post countertraction while the cast between the plaster segments is being completed.

Once the cast is applied, any indicated adjustment—such as lateral angulation by wedging, or shortening or distraction by double wedging—can be made.

Although this method was originally intended for fractures of the tibia and the fibula, it was found equally adaptable to femoral-shaft fractures by inserting the upper pin perpendicularly through the greater trochanter and the lower above or below the knee. Single-wire transfixion for traction and suspension treatment is also possible with the advantage of eliminating the metal stirrup and providing a rigid dressing about the wire, which prevents sliding and rotating of the wire, thus diminishing the chance of infection. A loop of rope is incorporated in the plaster collar for the attachment of traction.

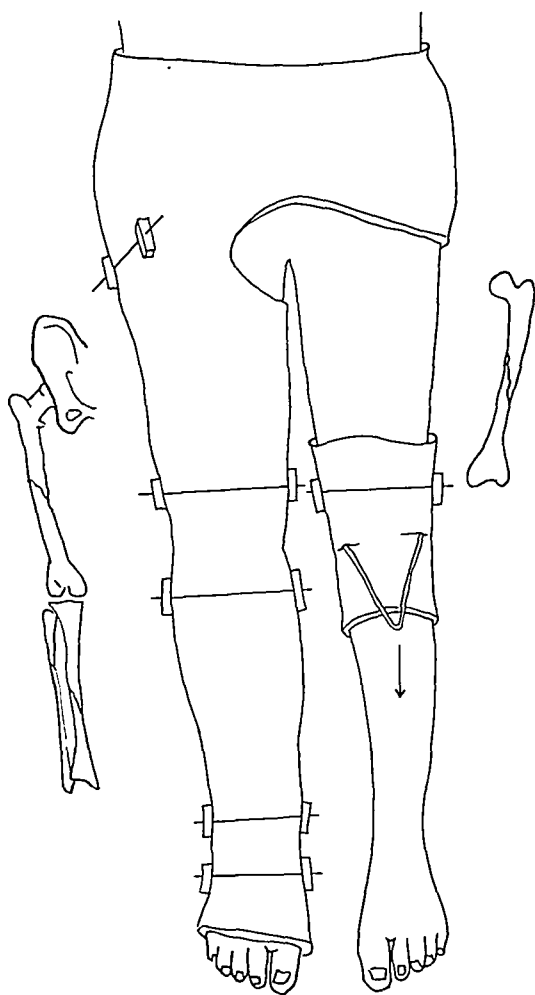


FIG. 2

Composite sketch showing treatment of femoral, tibial, and calcaneal fractures. On the left side, collar and clamps are substituted for a tensing bow in continuous-traction treatment.



# ORTHOPAEDIC RESEARCH IN NORTH AMERICA

## SURVEY OF THE RESEARCH COMMITTEE OF THE AMERICAN ORTHOPAEDIC ASSOCIATION \*

The Research Committee of the American Orthopaedic Association herein makes its first annual report on the present status of orthopaedic research in North America. The results of this survey should be most gratifying to all of us in orthopaedic surgery and justly we can take pride in the investigative work of our specialty. No attempt toward an exhaustive survey has been made; we have endeavored only to acquire an idea of the extent of orthopaedic research and to determine what problems are of the most common interest.

The report form which was sent was planned to be as simple as possible. Only seven headings were used; in addition to the subject of investigation, information was requested concerning whether the problem was clinical or laboratory, the place where the work was being done, the associated departments and workers, if any, and the character of the financial help, if any. In all of the replies these questions were clearly answered, which has tremendously simplified the analysis of the data.

Eight hundred and eight letters and report forms were sent out. These went to all members of the American Orthopaedic Association, the American Academy of Orthopaedic Surgeons, all diplomates of the American Board of Orthopaedic Surgery, the deans of the larger medical schools, the professors of paediatrics in the medical schools in which there are large children's clinics, and a few general surgeons interested in bone and joint problems. Replies were received from 261 or 32 per cent. of the total 808, which gives ample material for analysis. Of the 261 replies, 190, or 73 per cent., reported research problems and 71, or 27 per cent., reported no research problems. Of the 190 affirmative replies, there were only eight from other than orthopaedic surgeons. The 182 represent approximately 25 per cent. of all the orthopaedic surgeons and show that one in every four is actively engaged in research. These 190 have given information on 368 separate investigative problems, or an average of 1.94 problems per person. This information represents reports from seventy, or 84 per cent., of the eighty-three separate orthopaedic services training house officers, fellows, and postgraduate students, as listed in the 1939 report of the Committee on Graduate Education and Training in Orthopaedic Surgery of the American Academy of Orthopaedic Surgeons. It is the Committee's opinion that every major orthopaedic service is represented in this survey and a true picture is presented of the orthopaedic research in progress in North America at the present time. It cannot be said, of course, that all who did not reply are not carrying on active research. However, a great many not replying directly are mentioned as associate workers by those sending in the reports. In all, there were 190 names mentioned in the reports as associate workers. This number, added to the 190 who replied affirmatively, makes a total of 380 actively participating in orthopaedic research at this time.

An analysis of the location of the clinics where the work is being done is of interest. The Mayo Clinic stands at the top in number of problems, with a total of thirty-six. This work is being done by four senior staff members and twenty associates. The Service of the Boston Children's Hospital and the Massachusetts General Hospital is next with twenty-four problems being investigated by six senior staff members and seven associates. The Hospital for Joint Diseases is third with seventeen problems being investigated by ten senior staff members and three associates. The number of problems, of course, is no indication of the value of the research, but it is an indication of the interest and the attempt to stimulate research in these centers. An analysis of the number of research problems in some of the cities, not including Rochester, Minnesota, shows the

\* Presented at the Annual Meeting of the American Orthopaedic Association, Kansas City, Missouri, on May 7, 1940, by A. R. Shands, Jr., M.D., *Chairman*.

following: New York, sixty; Boston, thirty-one; Philadelphia, twenty-three; Chicago, twenty; San Francisco, sixteen; Los Angeles, fourteen; Baltimore, fourteen; etc. An analysis by the sections of the country, as adopted by the American Academy of Orthopaedic Surgeons for the Regional Committees shows:

<i>Section</i>	<i>Total No. of Problems</i>	<i>Total No. of Physicians Reporting Separate Problems</i>
New England States.....	39	18
Central Atlantic States.....	100	57
South Atlantic States.....	33	16
North Central States.....	119	50
South Central States.....	34	19
Northwestern States.....	6	6
Southwestern States.....	30	17
Canada.....	6	2
Mexico.....	1	1
Total.....	368	186

In an analysis of the data it is important to know whether or not laboratory studies are accompanying the investigation. This is true in 200 cases, or 54 per cent. of the total 368 problems. Of this number, forty-two, or 11 per cent. of the total, are purely laboratory problems unassociated with patients. The remaining 46 per cent. are purely clinical investigations. An analysis of the forty-two purely laboratory problems shows their character to be as follows: animal experiments, using dogs, monkeys, guinea pigs, mice, etc., thirteen; anatomical, ten; pathological, nine; biochemical, seven; anatomical and physiological, one; anatomical and pathological, one; and engineering, one.

There are 166 problems, or 45 per cent. of the total 368, in which fourteen other departments are mentioned as being associated in the research as follows:

<i>Department</i>	<i>No. of Problems</i>
Pathology, including Bacteriology.....	48
Roentgenology.....	46
Anatomy, including Histology.....	22
Medicine, including Paediatrics.....	16
Neuropsychiatry, including Psychology.....	7
Department of Laboratories.....	6
Biochemistry.....	5
Surgery.....	4
Neurosurgery.....	3
Endocrinology.....	3
Physiology.....	2
Engineering School.....	2
Urology.....	1
Physical Education.....	1
Total.....	166

It is very gratifying to know that thirty-eight of the institutions or schools where the investigations are being done have research funds which are available to the orthopaedic services. Special grants or gifts have been made to thirty-six of the 190 reporting research problems. The National Foundation for Infantile Paralysis is the donor in twenty-one instances. In three clinics some of the research is being financed by contributions from patients. Thirty-eight reported that all the finances incident to the research are being paid by themselves. It is most likely that the expenses incident to the remaining seventy-five physicians reporting separate problems are being met by the institutions

where the work is going on, in their normal budgets. There is no doubt that the specialty of orthopaedic surgery owes a great debt of gratitude to the National Foundation and it is hoped that the administration of their funds may continue to be such that those orthopaedic surgeons who have ideas and are stimulated to investigate problems relative to poliomyelitis can secure grants.

In making an analysis of the subject of investigation as recorded on each report, a classification, which is thought to be simple, with seventeen headings is used. (See Table I.) Under the first heading, General, are placed those problems relating to: (1) bone and bone formation, including all calcium-phosphorus studies; (2) special tissues, such as cartilage, ligaments, synovial membrane, etc.; (3) body systems, such as circulatory, urological, glandular, etc.; and (4) diet and vitamins. The second heading is Congenital Deformities; the third, Affections of Growing and Adult Bone, including epiphyses, and skeletal growth and development. In view of the fact that most of the leg-equalization work is in the young, this has been placed in this third group. The fourth heading, Infections of Bones and Joints, includes general, pyogenic, tuberculous, and syphilitic infections. The fifth is Chronic Arthritis. Affections of the Neuromuscular System is the sixth heading; this is divided into four groups with infantile paralysis first and cerebral palsy next. Tumors is the seventh heading; Fractures, the eighth; and Body Mechanics and Physical Therapy, the ninth. The next six are grouped according to body locations,—Spine, Hip, Knee, etc. The sixteenth heading is Technique, and is concerned mostly with operative procedures. The seventeenth and last heading is Miscellaneous.

The most popular group is Fractures, presenting forty-six problems, 26 per cent. of which are related to general subjects. It is interesting to note that there are studies on the effect of estrone and embryonic extract on the healing of fractures and a study of the comparison of fractures in blondes and brunettes. Eight studies are being carried on relative to compound fractures, with five of these relating to sulfanilamide therapy and two to x-ray therapy. Three-fifths of the fracture studies apply to special locations, with twelve problems on the hip — six of which relate to the use of Smith-Petersen nails or pins—four on the spine, and the other ten on ten different locations. Seventeen of the twenty projects listed under bone, bone formation, calcification, and calcium-phosphorus studies directly or indirectly relate to the repair of fractures and could be discussed with and included in this group. Considering this number, with the forty-six problems included under Fractures, this is easily seen to be the most popular subject of investigation, with a grand total of sixty-three problems.

The second most popular subject for investigation is Affections of the Neuromuscular System, with forty-four problems, seventeen of which relate to infantile paralysis. Sixteen of these seventeen are being wholly or partly financed by the National Foundation. The Committee is particularly delighted to see in this group that studies are being carried out on the pathology and biochemistry of paralytic muscle. There are seven studies on the after-care and evaluation of treatment in large groups of poliomyelitis cases which is certainly most important. Cerebral palsy is the subject of eleven projects, five of these being clinical studies, mostly with conservative treatment. The evaluation of curare in treatment of cerebral palsy, with a study of its biochemical and biological nature, may prove to be of distinct value in treating this discouraging affection. Six of the ten problems involving muscles, exclusive of infantile paralysis, are on progressive muscular dystrophy. Continued interest in this problem is important and it is gratifying to know of these experimental studies.

The third most popular group is Affections of the Spine, with thirty-four problems, seventeen being on the low back and fourteen on scoliosis. It is surprising to find, in spite of all the discussions concerning the intervertebral disc, only two investigations on this subject, with an equal number on the ligamentum flavum. There are seven, however, relating to some form of operation on the low back. One of the newer ideas is metallic osteosynthesis for low-back pain, which undoubtedly is the outcome of the work on vitallium and other metals. A piece of research, the results of which should be most

TABLE I  
CLASSIFICATION OF RESEARCH PROBLEMS

Classification	Total No. of Problems	Per Cent.	Classification	Total No. of Problems	Per Cent.
1. General.....	42	11.4	(1.) Cerebral palsy.....	11	
a. Bone, bone formation, calcification, and calcium-phosphorus studies.....	20		(2.) Others.....	2	
b. Joints.....	3		c. Peripheral nerves, exclusive of infantile paralysis.....	4	
c. Cartilage.....	1		d. Muscles, exclusive of infantile pa- ralysis.....	10	
d. Synovial membrane.....	3				
e. Tendon, tendon sheath, and bursa.....	1		7. Tumors of Bone.....	15	4.1
f. Fibrous tissue.....	6				
g. Blood and circulatory system.....	2		8. Fractures.....	46	12.5
h. Urological system.....	3		a. General.....	12	
i. Glandular system.....	3		b. Compound.....	8	
j. Vitamins and diet.....	2		c. Special locations.....	26	
2. Congenital Deformities.....	11	3.0	(1.) Hip.....	12	
a. Dislocation of the hip.....	6		(2.) Others.....	14	
b. Others.....	5		9. Body Mechanics and Physical Therapy.....	6	1.6
3. Affections of Bone.....	34	9.2	10. Affections of the Spine.....	34	9.2
a. Growing bone.....	5		a. General.....	3	
(1.) Epiphyses.....	5		b. Scoliosis.....	14	
(2.) Skeletal growth and de- velopment.....	26		c. Low back.....	17	
(a.) General.....	14				
(b.) In lower ex- tremity.....	11		11. Affections of the Hip.....	13	3.5
(c.) In spine.....	1		12. Affections of the Knee Joint.....	20	5.4
b. Adult bone.....	1		13. Affections of the Leg and Foot.....	15	4.1
4. Infections of Bones and Joints.....	33	9.0	14. Affections of the Neck and Shoulder.....	8	2.2
a. General.....	3		15. Affections of the Elbow, Forearm, Wrist, and Hand.....	5	1.4
b. Pyogenic.....	18		16. Technique.....	19	5.2
c. Tuberculous.....	9		a. General.....	2	
d. Syphilitic.....	3		b. Operative.....	17	
Chronic Arthritis.....	17	4.6	(1.) Procedures.....	7	
Affections of the Neuromuscular System.....	44	11.9	(2.) Metals.....	10	
a. Infantile paralysis.....	17				
b. Brain and spinal cord, exclusive of in- fantile paralysis.....	13		17. Miscellaneous.....	8	2.2
			Total.....	368	100.0

interesting, is an experimental study on monkeys, demonstrating the relationship of paralysis of the abdominal muscles to the development of scoliosis. Four of the fourteen scoliosis projects are on the idiopathic type, which is the subject for study by the Research Committee for next year. It is hoped that at the next Meeting of the American Orthopaedic Association we may have some very pertinent information to report on this subject.

Infections of Bones and Joints is fourth in order of popularity, with thirty-three problems, eighteen of which are pyogenic in character. Of considerable interest should be the studies on the blastomycosis and related affections of the skeletal system and granulomatous infections of bone. These subjects have been infrequent in the past, but more and more cases are now being diagnosed. One of the studies which bids fair to improve our therapy of pyogenic arthritis is that of the use of heparin in preventing the formation of fibrin in joints. It may be that, with the proper instillations or injections of heparin, joint adhesions can be completely eliminated and the incidence of ankylosis lessened. However, even more important than the heparin studies are the chemotherapeutic studies on infections. There are five studies on the use of sulfanilamide, or one of its derivatives, in the treatment of infections, making a total of ten sulfanilamide studies in all, when added to those classified under compound fractures.

Tuberculosis of bones and joints, with its varying problems, is the subject of nine investigations. Three of the studies are on spinal tuberculosis. The recent survey of this subject made by the Eastern States Orthopaedic Club, as reported at the Boston Meeting of the American Academy of Orthopaedic Surgeons, is probably the most complete and comprehensive end-result study of this type that has ever been made in the United States. It is certainly hoped that more of these types of study on our unsolved problems can be made in the future.

It is rather surprising that there are not more than three problems on syphilis of bones and joints, in view of the antisiphilitic campaigns which have been stimulated by the Public Health Service in the last few years. The answer may be that, due to the continued and effective antisiphilitic therapy, the orthopaedic clinics are now not seeing a large number of syphilitic infections of bones and joints.

Affections of Bone, with thirty-two problems, is the next most popular group. Thirty-one of these, however, relate to growing bone. Five problems deal specifically with the epiphyses and two with all the osteochondritides. Twenty-five of the thirty-one are concerned with skeletal growth and development, with eleven of these relating specifically to the lower extremity. Three very interesting x-ray and posture studies are being carried on in connection with the growth and development of the normal child, as parts of the study of the whole child from birth to puberty. These should be productive of most valuable data and are in a sufficiently large series to make the evidence worth while. Seven of the eleven problems in the lower extremity deal with the equalization of leg length. Certainly this has been a popular experimental study in the past and apparently still is.

Affections of the Knee Joint is the subject of twenty investigations. Four of these are anatomical in character; five relate directly or indirectly to internal derangements of the joint; three deal with cysts of the meniscus; one, with rupture of the quadriceps tendon; one, with Osgood-Schlatter disease; and two, with operative procedures on the removal, complete or partial, of the patella. This latter subject is worthy of careful study and may prove to be a very valuable adjunct to our present surgical knowledge of the knee joint.

Among the nineteen problems classified under Technique, there are two studies in which there is a search for a substitute for lipiodol in spinal myelography. Under operative procedures there are two studies on tendon transplantation,—one about the wrist and the other about the foot. There is one on the use of celloidin in arthroplasties. There are ten studies being conducted on the use of metal in the treatment of bone and joint conditions, five relating in some way to the use of vitallium.

In the group of studies on Chronic Arthritis, there are seventeen problems. Two

and the other an investigation of the effect of diet and vitamin therapy on skeletal development and maintenance and on the healing of fractures and various pathological lesions.

Under Miscellaneous there are three anatomical subjects,—namely, comparative anatomy: dynamics of histogenesis of nerve, muscle, tendon, bone, and joint; and the angle of tilt of the male pelvis. Two studies deal with pectin and the healing of wounds; one, with the split skin grafts; one, with braces; and one with the development of an orthopaedic fracture table. None of this group could well be classified with those previously mentioned.

#### CONCLUSIONS

1. This survey is based on 368 reports of research problems from 190 physicians.
2. One in four orthopaedic surgeons is engaged in investigative work.
3. The greatest number of investigators live in the Central Atlantic States, but the greatest number of problems are being investigated in the North Central States.
4. Eleven per cent. of the problems are wholly laboratory studies; 43 per cent. are laboratory and clinical; and 46 per cent. are clinical.
5. There are thirty-eight institutions or schools with research funds available to the orthopaedic department, and there are thirty-six grants or gifts for orthopaedic research now being made by foundations, etc.
6. The following departments of medicine, in this order, are most frequently associated in orthopaedic research: pathology, roentgenology, anatomy, and medicine, including paediatrics.
7. The following five subjects of investigation are the most popular, in this order: fractures, neuromuscular disorders, affections of the spine, infections of bones and joints, and affections of growing and adult bone.

Submitted by

The Research Committee

JOSEPH S. BARR, M.D., Boston, Massachusetts

PAUL C. COLONNA, M.D., Oklahoma City, Oklahoma

A. R. SHANDS, JR., M.D., Wilmington, Delaware, *Chairman*

of these are pathological in character; two are studies on the liver function in arthritis; two are on arthritis of the spine; and one is on the surgery of degenerative arthritis of the knee. There is a very interesting study on the physiological response to the correction of the adduction deformity in chronic osteo-arthritis of the hip. This might prove to be a tremendously helpful operative procedure in these old cases of painful hip. The use of snake venoms is being studied in one instance. There are two studies on chemotherapy in arthritis; one, on fever therapy; one, on x-ray therapy; and two are general clinical laboratory studies of arthritis. There is undoubtedly more interest being manifested by the orthopaedic surgeon in the investigative side of arthritis than ever before.

Tumors of Bone and the related structures have always been of interest to orthopaedic surgeons. There are fifteen problems in this field of research. Cysts and cystic degeneration of bone is the subject of two investigations. There are five studies on malignant bone tumors and their diagnostic features. Neurofibromatosis and its relationship to bone growth and deformities is a valuable contribution in this group. There are two investigations on new types of bone tumors,—namely, osteoid-osteoma and eosinophilic granuloma.

There are fifteen studies on Affections of the Leg and Foot. Seven of these are anatomical in character, relating to bones and muscles of the foot. Four deal with pronation and depression of the longitudinal arch; one, with an increase of the longitudinal arch or cavus foot; one, with the end results of stabilization; one, with the heel; and one, with the making of special shoes for unusually shaped feet.

Affections of the Hip is the topic of thirteen investigations. Three are anatomical in character; five deal with coxa plana; and three are concerned with slipping of the capital epiphysis.

Congenital Deformities is the subject of eleven studies. Six of these relate to congenital dislocation of the hip and two to club-foot.

There are eight problems on Affections of the Neck and Shoulder. Four of these are concerned with the stiff and painful shoulder; one, with acromio-clavicular separation; one, with torticollis; and two, with affections of the cervical vertebrae.

There are only six problems on Body Mechanics and Physical Therapy. Two of these are very excellent studies on the biomechanics of gait.

Affections of the Elbow, Forearm, Wrist, and Hand are subjects of study in five instances. One of these is a very interesting study on the kinesiology of the hand and was recently presented at the Academy Meeting in Boston. There are two studies on Dupuytren's contracture.

Under the first heading, General, there are forty-two problems. Studies relating to bone, bone formation, calcification, and calcium phosphorus are the most numerous, there being twenty. There are five problems in this group on calcium-phosphorus metabolism. The other problems relate to bone-grafting, bone formation, and calcification in general. There is one very interesting laboratory study on the relation of the available protein in the organism to the regeneration of bone. A study which bids fair to throw light on the basic knowledge of cartilage is being conducted on the chemistry of normal and arthritic articular cartilage. There are six studies with reference to the blood and circulatory system. One investigation which should be productive of valuable information is entitled: "A Blood-Flow Study in Muscle Diseases, Primarily Poliomyelitis and Secondarily Dystrophies".

A great deal has been written recently on the subject of the glandular system and joint changes. However, there are only four problems in any way connected with this subject, one of these being the effect of estrone on the healing of fractures, as mentioned previously. It is certainly to be hoped that from such studies as "A Search for the Hormones of Skeletal Maturity" and "The Effects of Various Hormones on the Skeletal System" real contributions to orthopaedic surgery may result.

Vitamins and diet have occupied a very important place in our medical literature. However, there are only two studies in connection with vitamin therapy and diet, one being a study in animals of the effect of acute and chronic vitamin-C deficiency on joints,

and the other an investigation of the effect of diet and vitamin therapy on skeletal development and maintenance and on the healing of fractures and various pathological lesions.

Under Miscellaneous there are three anatomical subjects,—namely, comparative anatomy; dynamics of histogenesis of nerve, muscle, tendon, bone, and joint; and the angle of tilt of the male pelvis. Two studies deal with pectin and the healing of wounds; one, with the split skin grafts; one, with braces; and one with the development of an orthopaedic fracture table. None of this group could well be classified with those previously mentioned.

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## BRITISH ORTHOPAEDIC ASSOCIATION

The British Orthopaedic Association held its Spring Meeting in London on May 3, 1940, under the Presidency of Prof. T. P. McMurray. The meeting took place at Manson House and was attended by a large number of members. At the Association dinner at the Langham Hotel on the same evening, the guests included Lieut.-General Sir William McArthur, the Director General of the Army Medical Service, and Col. J. A. MacFarlane of the Canadian Army Medical Service.

In the morning a series of short papers were presented, and in the afternoon the Association attended the Royal National Orthopaedic Hospital, the staff of which presented a varied and instructive clinical demonstration.

A résumé of the short papers follows:

*Tuberculous Arthritis of the Ankle and Tarsus* by Mr. W. R. J. Mitchell, Liverpool.

A series of 169 patients were reviewed; of these it had been possible to follow up in detail seventy-seven children and forty-five adults. The conclusions drawn were that an excellent result follows prolonged and efficient conservative treatment in children, while in adults, especially over the age of forty-five, amputation without delay is probably the best treatment rather than conservative therapy or the less radical operative measures such as attempted excision of foci or arthrodesis. An important observation was that the poor results, including death, in adults were due to tuberculous lesions in other parts of the body, which appeared subsequent to the conservative treatment of the original focus; whereas of fourteen patients in whom amputation was performed early, thirteen appeared completely cured.

*Extirpation of the Pronator Quadratus Muscle for Spastic Paralysis* by Mr. Robert I. Stirling, Edinburgh.

Mr. Stirling expressed the view that many pronation contractures are due to a contracted pronator quadratus. Extirpation of the latter muscle, followed by intensive reeducation of the biceps and supinator muscles, had achieved good results in sixteen patients. A well-illustrated survey of the anatomy of the pronator quadratus was given.

*Ischiofemoral Arthrodesis* by Mr. H. A. Brittain, Norwich.

Mr. Brittain, in an elaboration of a previous communication, outlined the advantages of ischiofemoral extra-articular arthrodesis of the hip as opposed to iliofemoral arthrodesis, especially in the late treatment of tuberculous disease. The operation consisted of a subtrochanteric osteotomy, through which the ischium immediately below the acetabulum was "raved". A large autogenous bone graft was inserted between the femoral fragments and embedded deeply in the ischium. The procedure had proved successful in achieving bony ankylosis in twenty of the twenty-eight patients in Mr. Brittain's series.

*Stresses, Strains, and Spondylolisthesis* by Mr. Norman Capener, Exeter.

In this review of spondylolisthesis Mr. Capener discussed the importance in general of a proper appreciation of stresses and strains in orthopaedic conditions as understood in dynamics and statics. The cause of the underlying defect in the interarticular portion of the neural arch (spondylolysis) is still *sub judice*, but the possibility of chondrovascular defects in the neural arch is considered important. Of the anatomical and mechanical conditions limiting displacement of the vertebral body, the iliolumbar ligaments and an intact nucleus pulposus appear of particular importance. At all ages treatment should be conservative with two exceptions: (1) when evidence of increasing displacement is present in adolescence, and (2) when pain persists in spite of conservative measures. In both exceptions a posterior spine fusion should be performed. The anterior transperitoneal fusion is condemned as unnecessary and unjustifiably dangerous.

*Dislocation of the Carpal Semilunar* by Mr. F. W. Holdsworth, Sheffield.

A series of eighteen cases was reviewed. Following a study of the anatomy and mechanism of the wrist, Mr. Holdsworth concluded that normal dorsiflexion entails a

screw movement, finally locked by impaction of the os magnum on the scaphoid and the scaphoid on the radial styloid process. Violent dorsiflexion tends to "strip the thread", and the main strain falls in the region of the apex of the screw—that is, the head of the os magnum—producing one of the several forms of so-called dislocation of the semilunar bone. It was emphasized that manipulative reduction of a recent dislocation can most easily be achieved by traction in *palmar flexion*, since this position opens up most widely the space between the os magnum and the radius. In injuries neglected for longer than fourteen days, excision of the semilunar provides better results than operative replacement, for the latter procedure is often followed by sclerosis of the bone and osteoarthritis of the wrist. Results are not so satisfactory if it is necessary to remove more than the semilunar.

*The Reaction of Bone to the Pressure of Fluctuant Tumors* by Mr. V. H. Ellis, London.

Mr. Ellis commented on the lack of knowledge about the factors which stimulate osteoblastic or osteoclastic activity, but stated that it is generally agreed that osteoclasts are the only cause of bone absorption. The latter is the normal response of bone to continuous pressure, but there are differences between the results of pressure by hard and by fluctuant tumors,—for example, aneurysms, abscesses, and bursae. In these, although absorption takes place, there is always a line of resistance formed by osteoblastic activity.

The Annual Meeting of the Association will be held in Liverpool on October 25 and 26, 1940.

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#### AMERICAN ORTHOPAEDIC ASSOCIATION

The Fifty-Fourth Annual Meeting of the American Orthopaedic Association was held at the Hotel President, Kansas City, Missouri, on May 6, 7, 8, and 9, 1940, under the Presidency of Dr. Frank D. Dickson. The morning of the first day was devoted to a clinical meeting with reports and demonstrations of cases by the following: Dr. C. B. Francisco, Dr. Earl C. Padgett, Dr. Frank R. Teachenor, Dr. Robert McE. Schaffler, Dr. Ferdinand C. Helwig, Dr. Rex L. Diveley, and Dr. Frank D. Dickson.

At the scientific sessions held on the other three days, the following papers \* were presented:

*The Obstetrical Experiences of Women Paralyzed by Acute Anterior Poliomyelitis*—Dr. S. Kleinberg, New York, N. Y., and Dr. Thomas Horwitz, Philadelphia, Pennsylvania (by invitation).

These authors described distortion of the pelvis in sacrolumbar scoliosis and stated that they had found this deformity in 80 per cent. of the cases. Their studies show that it has practically no effect upon delivery, and no therapeutic abortion is recommended. Spine fusion does not seem to have any effect on childbirth.

*Studies of the Cell in Normal and Arthritic Bovine Cartilage*—Dr. George Wagoner Philadelphia, Pennsylvania.

In this paper, dealing with the histology and biochemistry of the cartilage, young adult and old cartilage were compared. Bovine cartilage was used for the experiments. Of interest are the cartilage cell count and the correlation between cell count and age. The nuclear measurements vary greatly; their average is ninety cubic micromillimeters, but this changes with age. Of particular interest are the metabolic changes: the oxygen consumption decreases rapidly with age, much more rapidly than does the cellular density. Dehydrogenation was also studied, and it was found that old cartilage loses but little in hydrogen mobilization.

\* Summaries of papers taken from a report prepared by Dr. Arthur Steindler.

*The Surgical Treatment of Degenerative Arthritis of the Knee Joint.*—Dr. G. E. Haggart, Boston, Massachusetts.

This paper deals with synovectomy for degenerative arthritis of the knee. Excision of the patella is advised. It is pointed out that the patella is behind the tendon and can be shelled out without injury to the extensor apparatus. Following synovectomy, manipulation is favored. The author feels that in selecting the cases for this operation one should bear in mind the following important factors: willingness of the patient to cooperate fully in the postoperative regimen; quiescence of the disease; and use of this procedure only for cases of the degenerative type of arthritis.

*On the Conservative Compensation-Derotation Treatment of Scoliosis.*—Dr. A. Steindler, Iowa City, Iowa, and Dr. C. W. Ruhlin, Iowa City, Iowa (by invitation).

The authors discussed the treatment of scoliosis by compensation and derotation, explaining the rationale of this method and classifying the cases in which it is indicated in five groups, as follows: (1) spontaneous compensation, (2) compensation accomplished by conservative treatment, (3) compensation effected by conservative treatment but prone to secondary decompensation, (4) compensation accomplished but unstable, and (5) uncompensable cases. Cases of permanent correction were demonstrated.

*A Study of Paralytic Scoliosis Based on 500 Cases of Poliomyelitis.*—Dr. Paul C. Colonna, Oklahoma City, Oklahoma, and Dr. Frederick vom Saal, Oklahoma City, Oklahoma (by invitation).

From their study the authors found that 30 per cent. of all cases of poliomyelitis show paralytic scoliosis. Of their series of 150 cases of paralytic scoliosis a diminished vital capacity was noted in all. The treatment which they advocate consists in the application of a Risser cast, derotation, and operation.

*Acetabuloplasty: An Analysis of Results.*—Dr. M. N. Smith-Petersen, Boston, Massachusetts.

Dr. Smith-Petersen feels that the advantage of acetabuloplasty is that it affords a good approach to and complete exposure of the joint. In the cases in which he had performed this operation prior to 1938 he was able to show good results—that is, lessening of pain and fair motion—in about 50 per cent. Since 1938 he has substituted cup-plasty for acetabuloplasty in most instances.

*Osteoid-Osteoma: Further Experience with This Benign Tumor of Bone. With Special Reference to Cases Showing the Lesion in Relation to Shaft Cortices and Commonly Misclassified as Instances of Sclerosing Non-Suppurative Osteomyelitis or Cortical-Bone Abscess.*—Dr. Henry L. Jaffe and Dr. Louis Lichtenstein, New York, N. Y. (by invitation.)

The condition described by these authors appears to be an entirely new pathological entity,—namely, the formation of a bony nidus or nucleus in the spongiosa or cortex of the bone, surrounded by an osteosclerotic zone. According to the pathological findings, this is not an inflammation but a neoplasm.

*Subtrochanteric Osteotomies: Indications for Special Types.*—Dr. Frederick C. Kidner, Detroit, Michigan.

The author described cases in which subtrochanteric osteotomies of the Lorenz-McMurray type had been performed in cases of ununited fracture. He showed a number of interesting slides in which the subtrochanteric osteotomy was employed in tuberculosis of the hip joint, according to the method of Farkas.

*Ununited Fracture of the Femur Treated by High Oblique Osteotomy.*—Dr. Rudolph S. Reich, Cleveland, Ohio.

Dr. Reich finds that nailing in cases of ununited fracture produces union in about 64 per cent., but arthritis develops in almost 50 per cent. Therefore, he believes the bifurcation operation to be more widely indicated. He defines old fractures as those which are

of three weeks' or more duration. Although not necessary for a good end result, union of the original fracture often occurs spontaneously. Of the twenty-six cases in his series, the author was able to report the end results in twenty-five: there were good results in twenty-two, and failures in three.

*Orthopaedic Research in North America. Survey of the Research Committee of the American Orthopaedic Association*—Dr. Joseph S. Barr, Boston, Massachusetts, Dr. Paul C. Colonna, Oklahoma City, Oklahoma, and Dr. A. R. Shands, Jr., Wilmington, Delaware, *Chairman*.

Dr. Shands, as Chairman of the Research Committee appointed by the American Orthopaedic Association, gave a detailed report of the orthopaedic research problems now being investigated in North America. (See page 752.)

*Some Orthopaedic Relationships of Neurofibromatosis* [Candidate's Thesis]—Dr. Beveridge H. Moore, Chicago, Illinois.

The author reported four cases showing deformities, hypertrophy of bone, and tumor masses in the soft tissues between the skeleton and dorsum of the foot. Biopsy revealed neurofibromata, and the clinical study showed a definite relationship between the hypertrophy, the deformities, and the tumors. Dr. Moore also reported three cases of pseudarthrosis following osteotomy, in which signs of Recklinghausen's disease were found in the skin, naevi, etc. The roentgenogram shows cessation of bone growth and a cystic type of trabeculation with definite signs of deficient osteogenesis.

*The President's Address*—Dr. Frank D. Dickson, Kansas City, Missouri.

This address dealt with the scope and development of the American Orthopaedic Association and contained some very sound suggestions and proposals in regard to the contribution which the Association can make in the future. (See page 525.)

*Symposium on the Incidence, Significance, and Treatment of Sciatic Pain in Low-Back Cases*—Dr. Fremont A. Chandler, Chicago, Illinois, *Chairman*.

Dr. Theodore A. Willis, Cleveland, Ohio, considered the "Anatomical Variations as Well as the Roentgenographic Appearance of the Low Back", and Dr. W. McK. Craig and Dr. Maurice N. Walsh, Rochester, Minnesota, were invited to discuss "Neuro-Anatomy and Physiology". Dr. John G. Kuhns, Boston, Massachusetts, dealt with the "Conservative Treatment". The subject of the "Intervertebral Disc" was handled by Dr. Joseph S. Barr, Boston, Massachusetts, and Dr. William Jason Mixter, Boston, Massachusetts (by invitation). Dr. Benjamin P. Farrell, New York City, and Dr. W. B. MacCracken, New York City (by invitation), discussed "Lumbosacral Lesions with the Exception of Spondylolisthesis". Dr. M. N. Smith-Petersen, Boston, Massachusetts, dealt with "Sacro-Iliac Conditions", and Dr. Henry W. Meyerding, Rochester, Minnesota, considered the "Incidence, Significance, and Treatment of Low Backache and Sciatic Pain Associated with Spondylolisthesis". The rôle of the "Fascia" in this affection was discussed by Dr. Frank R. Ober, Boston, Massachusetts, Dr. Clarence H. Heyman, Cleveland, Ohio, and Dr. Albert H. Freiberg, Cincinnati, Ohio.

The discussion of the various phases of the subject which were presented in the Symposium was participated in by Dr. George E. Bennett, Baltimore, Maryland; Dr. Lawson Thornton, Atlanta, Georgia; Dr. W. McK. Craig, Rochester, Minnesota; Dr. James A. Dickson, Cleveland, Ohio; Dr. Rex L. Diveley, Kansas City, Missouri; Dr. James S. Speed, Memphis, Tennessee; Dr. Harold H. Hitchcock, Oakland, California; and Dr. Halford Hallock, New York City.

*A Simple Method of Two-Stage Transplantation of the Fibula for Use in Cases of Complicated and Congenital Pseudarthrosis of the Tibia*—Dr. Philip D. Wilson, New York, N. Y.

The two-stage operation described by Dr. Wilson—fusion of the fibula into the tibia—is done even in the presence of some infection. Six cases of pseudarthrosis were treated

in this manner, and spontaneous union occurred. In cases of non-union, the implantation of the fibular graft into the tibia is supported by additional sliver grafts.

*Legg-Perthes Disease of the Hip, Its Early X-Ray Manifestations, and Its Cyclical Course*.—Dr. A. Bruce Gill, Philadelphia, Pennsylvania.

Dr. Gill stated that the degenerative phase of Legg-Perthes disease lasts from one to one and one-half years, that the regenerative phase is from two to three years, and that elimination of weight-bearing shortens the cycle. He pointed out that roentgenographically the primary changes are in the metaphyses; these show bone degeneration at the head and massive necrosis follows later, but the aseptic necrosis involves the head as well as the head. The etiology of the deformities is purely mechanical,—weight-bearing upon the softened head. The treatment consists of bed rest, extension, and prolonged immobilization.

*The Treatment of Claw-Foot*—Dr. Wallace H. Cole, St. Paul, Minnesota.

In this paper the idiopathic as well as the acquired type of claw-foot was discussed. Dr. Cole described the general treatment and the technique of the operations which are used. He believes that in the more advanced cases the tarsal-wedge osteotomy should be performed in front of the mid-tarsal joint.

*The Local Use of Sulfanilamide in Various Tissues*—Dr. J. Albert Key, St. Louis, Missouri, Dr. Charles J. Frankel, St. Louis, Missouri (by invitation), and Dr. T. B. Burford, St. Louis, Missouri (by invitation).

The bacteriostatic effect of sulfanilamide was discussed, and it was stated that treatment should be supported by the use of immune serum. The incubation period is from six to eight hours, and the drug is highly selective. So far as the local effect is concerned, experiments showed that it does not affect the healing of incisions. The introduction of the drug into the wound or its injection into the joint when the wound is closed with normal saline also has no appreciable effect on healing. When used in operative wounds in powder form or locally implanted in contaminated wounds, sulfanilamide promotes rapid healing.

*Sulfanilamide in the Treatment of Compound Fractures*—Dr. Willis C. Campbell, Nashville, Tennessee.

This paper was read by title.

At the last Executive Session, the following officers were elected:

President-Elect: Dr. George E. Bennett, Baltimore, Maryland.  
Vice-President: Col. Norman T. Kirk, San Francisco, California.  
Secretary: Dr. Charles W. Peabody, Detroit, Michigan.  
Treasurer: Dr. Rex L. Diveley, Kansas City, Missouri.

The following Members of Committees and Delegates were elected:

Member of Membership Committee: Dr. Paul C. Colonna, Oklahoma.  
Member of Program Committee: Dr. Herman C. Schumm, Milwaukee, Wisconsin.  
Delegate to the American College of Surgeons, Dr. J. Archer O'Reilly, St. Louis, Missouri.

The President for the current year is Dr. D. E. Robertson, Toronto, Ontario.  
Elected to active membership in the Association were the following:

Dr. Guy A. Caldwell, New Orleans, Louisiana.  
Dr. Juan Farill, Mexico City, Mexico.  
Dr. C. H. Hatcher, Chicago, Illinois.  
Dr. Alberto Inclán, Habana, Cuba.  
Dr. Harry B. Macey, Rochester, Minnesota.  
Dr. Nicholas B. Ransohoff, New York, N. Y.  
Dr. William J. Stewart, Columbia, Missouri.  
Dr. Atha Thomas, Denver, Colorado.

# Current Literature

HANDBOOK OF ORTHOPAEDIC SURGERY. Alfred Rives Shands, Jr., B.A., M.D. in collaboration with Richard Beverly Raney, B.A., M.D. Ed. 2. St. Louis, The C. V. Mosby Co., 1940. \$4.25.

The complaint of students that most orthopaedic reference books are too much like encyclopedias has perhaps been justified. Most of these have been voluminous, detailed, and intended as sources of reference for orthopaedic surgeons rather than as textbooks for students.

Shands, in writing the "Handbook of Orthopaedic Surgery", in collaboration with Raney, has made a real contribution. The demands for the first edition were so great that a second edition had to be issued in a comparatively short time.

As stated in the preface, this is a concise textbook of contemporary orthopaedic surgery, brought up to date. It contains, in addition to brief but adequate discussions of all of the commonly encountered orthopaedic conditions, a bibliography of outstanding articles written in English prior to July 1939.

The text is easy to read and easy to understand. It has been generously illustrated with artist's drawings which emphasize the anatomical relationships or pathological conditions under discussion.

It is to be hoped that those medical schools in which the teaching of orthopaedic surgery has been superficial or entirely neglected, will be encouraged to give this subject more consideration and to make use of this excellent text in the planning of lectures, in the presentation of clinical material, and by recommending it to students.

MINOR SURGERY. Frederick Christopher, S.B., M.D., F.A.C.S. with a Foreword by Allen B. Kanavel, M.D., F.A.C.S. Ed. 4. Philadelphia and London, W. B. Saunders Co., 1940. \$10.00.

This edition in one volume of 946 pages, with 639 illustrations, describes the treatment of minor surgical conditions encountered by the physician in a typical general practice. The ever-increasing burden placed upon the teaching of medical students, because of the more intensive instruction in the basic sciences and rapid advance in medicine, often leaves but little time for consideration of minor conditions.

In this age of frequent automobile or industrial accidents, physicians not connected with large hospitals, or especially skilled in surgery, are often confronted with minor surgical problems. All too often such a minor condition becomes a major one as a result of lack of knowledge or careless technique. In this book nearly every minor surgical condition that a general practicing physician would be apt to meet is briefly but concisely described and treatment outlined. Illustrations are numerous and informative. The subject matter is so arranged and indexed that the information desired is readily obtained.

The fourth edition is not a copy of its predecessors. The whole volume has been revised, many chapters have been entirely rewritten, and in others old material has been replaced by new. Some of the new procedures described are: newest factors in wound healing, including vitamins; sulfanilamide therapy for various conditions; latest methods in the treatment of burns; injection therapy; care of minor industrial and automobile injuries; new intravenous therapy; postoperative management of water balance; and Wangenstein suction technique. In addition to these, there are many excellent chapters such as those on treatment of open and closed wounds, head injuries, infections of the neck, infections of the hand, and injuries to the lower extremity.

Perhaps one of the most valuable chapters is that devoted to the surgical interne. Here he can learn many of the things which he is often left to discover for himself by the trial-and-error method.

Taken all in all, this book is excellent for that which the title professes—minor surgery. For the interne, the physician not allied with a large modern hospital, or the busy general practitioner, "Minor Surgery" will be of inestimable value in bringing to him the newest in minor surgical practice.

**CURA OPERATORIA DELLE FRATTURE DEL COLLO DEL FEMORE** (Operative Treatment of Fractures of the Neck of the Femur). Prof. V. Putti. Bologna, L. Cappelli, Editore, 1940. 60 lire.

This monograph gives Prof. Putti's methods of treating, by operative means, fractures of the femoral neck. The first part contains chapters on the history of skeletal fixation; the classification; general statistics with regard to incidence, sex, age, and types of fractures; and statistics concerning their treatment.

In the fourth chapter of this part an anatomical analysis is made, and the conditions produced by the use of a screw are described.

The fifth chapter gives the indications and contra-indications for skeletal fixation.

In the subsequent chapters Prof. Putti describes in detail his method of fixation by means of a screw; gives notes on the postoperative treatment; and states the results.

In the second part of the monograph the author gives his methods of treatment of old fractures of the neck of the femur, giving the indications and contra-indications for osteotomy. The author's reasons for each detail of the treatment are stated and the book is abundantly illustrated.

**THE FOOT AND ANKLE: THEIR INJURIES, DISEASES, DEFORMITIES AND DISABILITIES.** Philip Lewin, M.D., F.A.C.S. Philadelphia, Lea & Febiger, 1940. \$9.00.

When the variety of conditions which may affect the foot and ankle are considered as a whole, they trespass on the precincts of numerous specialties beyond the strict field of orthopaedic surgery. Heretofore textbooks have somewhat neglected these outlying topics and have concentrated on the major specialty, but there is a growing tendency among modern authors to break away from this custom and to present the subject in all its aspects. Such treatment greatly enlarges the value of the book from the standpoint of the general practitioner.

Dr. Lewin has presented his studies from this viewpoint, and a glance at the subject matter reveals the wide range of topics which he has covered. The usual static and mechanical strains are fully discussed with a clear exposition of the basic principles underlying them. There are detailed chapters on specific deformities, congenital defects, and bone affections. Space is devoted to the minor complaints which so often puzzle the practitioner, and the uncommon and rare conditions also receive adequate notice. Industrial, athletic, and military injuries are described in a very practical survey. Besides such standard orthopaedic topics as arthritis, poliomyelitis, and spastic paralysis, there are some very worth-while chapters on circulatory disorders, skin affections, and neurological lesions. In addition, the field of traumatic surgery is represented by full discussions of fractures, dislocations, and amputations.

One point of particular interest is the theory which Dr. Lewin has advanced of a new cause of metatarsalgia, due, he believes, to the posture in sitting with the heels off the floor and the toes turned up like a ballet dancer. The pressure thus exerted on the metatarsal heads exaggerates the depression of the anterior arch and may be, in his opinion, a very common factor in foot strain.

Such a hasty review of the material included in this book fails to reveal the excellent quality of the articles themselves. Perhaps it is enough to say that they are distinguished by clear and concise exposition, by a wealth of practical suggestions, and by their very successful illustrations. An unusual appendix has been added under the witty title of "Pedigrams", containing a collection of epigrams on the subject of the foot.

Altogether this text deserves close study by orthopaedic surgeons as a whole and by the rank and file of general practitioners as well.

**CONGENITAL MALFORMATIONS. A STUDY OF PARENTAL CHARACTERISTICS WITH SPECIAL REFERENCE TO THE REPRODUCTIVE PROCESS.** Douglas P. Murphy, M.D., F.A.C.S. Philadelphia, University of Pennsylvania Press, 1940. \$2.00.

From the Gynceean Hospital Institute of Gynecologic Research the author reports an extensive statistical study of parental characteristics with special reference to the reproductive process and to the occurrence of congenital malformations. From this study, based on an investigation of 600 couples, a series of thirty-two conclusions are drawn by Dr. Murphy, which, in general, bear out the belief that congenital malformations are definitely hereditary. It is surprising that, in this series, syphilis, as indicated by the Wassermann blood test, does not appear to afflict the mothers of congenitally malformed offspring more often than those of children who are normally developed at birth. The conclusion that the diets of the mothers of defective children are significantly lacking in adequate amounts of calcium, phosphorus, iron, and vitamins B, C, and D requires further evaluation. In view of the wide extent of these deficiencies, it seems doubtful whether this factor bears any more definite relation to congenital malformations than does syphilis.

The most significant contribution of this important piece of research is summed up in the final general conclusion: "Gross human congenital malformations arise solely from influences which affect the germ cells prior to fertilization. No evidence is available to indicate that they result from factors which operate for the first time after fertilization has taken place."

**PRINCIPLES OF ORTHOPEDIC SURGERY.** James Warren Sever, M.D. Ed. 3. New York, The Macmillan Co., 1940. \$3.25.

This work of which the present volume, entitled "Principles of Orthopaedic Surgery" is the third edition first appeared in 1924 under the title, "Text Book of Orthopedic Surgery". In truth, neither designation is entirely correct for this excellent series of lectures on orthopaedic topics. The author notes in his preface that the material in this book is the result of many lectures on orthopaedic surgery to students and nurses.

For the general practitioner or the student, it offers a vivid and interesting presentation of the material of orthopaedic surgery. In large part, the text of the original volume has been incorporated into the present edition, but numerous additions of more recent studies in orthopaedic surgery have been made. These addenda are extremely valuable in that they present the single viewpoint of the author's maturity. But for this very reason the experienced orthopaedic surgeon, who is often interested in diversity of opinion, may not find the work so significant as it must certainly prove to be to the student. The text is clear, the indications are unequivocal, and the illustrations are excellent.

**A SYNOPSIS OF SURGERY.** Ernest W. Hey Groves, M.S., M.D., B.Sc. (Lond.), F.R.C.S. (Eng.). Ed. 11. Baltimore, The Williams & Wilkins Co., 1940. \$5.00.

This book, as its title implies, gives only the essentials of the practice of surgery. It is not intended to supplant the more detailed and complete textbooks, but, rather, to supplement them. Its concise and orderly arrangement of facts enables the busy practitioner to obtain quickly and easily the fundamental points in diagnosis and treatment. That it has reached the eleventh edition is evidence of its favorable reception by the medical profession.

The text in this latest edition has had complete revision; it includes the recent information on the subjects which are creating so much interest at present, replacing some of the older material which has now become less accurate or important. The book deserves the continued popularity which the previous editions have enjoyed.

**ESTUDO SOBRE DORES LOMBARES (A Study of Lumbar Pain).** Orlando Pinto de Souza. São Paulo, Empresa Gráfica da "Revista dos Tribunais", 1939.

This large, paper-bound monograph with many roentgenograms and other illustrations, printed on excellent paper, presents an interesting and careful study of the problem.



The author recognizes the immensity of the subject and, therefore, limits his study to the so-called rheumatic affections of the spine, including certain congenital malformations.

The author relates the results of his own experiences and the accepted views of many of the European and, especially, of the American orthopaedic surgeons. In consecutive chapters, he gives a keen, critical analysis of differential signs described in the orthopaedic literature and attempts to show the great importance of arthritis of the articular facets of the lumbar vertebrae and the ensuing involvement of the intervertebral foramina in relation to causation of pain. The pathogenesis of lumbar pain and its irradiation are treated at some length in connection with the anatomy of the foramina and statics and dynamics of the spine. The problems connected with the intervertebral disc, spondylolisthesis, and anatomical anomalies are presented in the light of coexisting and secondary arthritic changes in the articular processes of the vertebrae.

In the final chapter the treatment is discussed in a thorough and illuminating manner. An operative procedure is described and well illustrated. It consists of a fusion of the lumbar spine with placement of two bone grafts—one in each paravertebral groove—and of removal of the articular processes of the vertebrae to enlarge the intervertebral foramina. An extensive bibliography is appended.

CARE OF POLIOMYELITIS. Jessie L. Stevenson, R.N. New York, The Macmillan Co., 1940. \$2.50.

This book is written by a nurse with many years' experience in public health nursing, and presents material of value to those in the field of public health and orthopaedic nursing.

An account is given of the growth of public interest in poliomyelitis, and a summary of the accomplishments in research, control, and after-care by such organizations as The National Foundation for Infantile Paralysis, Harvard Infantile Paralysis Commission, Georgia Warm Springs Foundation, and the Visiting Nurse Associations of Brooklyn and Chicago.

Brief descriptions of the etiology, pathology, control of epidemics, course of attack, treatment through the various stages of the disease, educational facilities, and vocational work are presented. Credit is given to the proper authorities at the close of each chapter.

Complete instruction is given for bedside nursing, protection of affected muscles, prevention of deformity, psychology of adjustment of family and patient, and cooperation with the medical profession and available agencies. Many helpful suggestions for the use of home facilities, adjustments of beds, and protective apparatus, while not new, are well repeated here. In the appendices are reprinted from *The Physiotherapy Review* directions for making simple splints. The illustrations are an adjunct to the text.

The very limited explanations of the use of heat, massage, muscle testing and training, and exercises in water are not adequate instruction for their use. Only enough information is given to acquaint the reader with these modalities. The author, because of her training, naturally gives a preponderance to a nurse's viewpoint.

Supervisors and instructors of public health nurses will find much teachable material in this book.

THE MEDICAL ANNUAL, 1940. Edited by H. Letheby Tidy, M.A., M.D., F.R.C.P., and A. Rendle Short, M.D., B.S., B.Sc., F.R.C.S. Bristol, John Wright & Sons, Ltd., 1940. 20 shillings.

The present edition of the *Annual* is the fifty-eighth, and follows closely the general scheme of its predecessor which was reviewed in *The Journal* of October 1939. This year the *Annual* consists of 604 pages of text, 62 text illustrations, 65 plates, plain and colored, and a practitioner's index of new pharmaceutical and dietetic preparations, medical and surgical appliances, etc. This is followed by a chapter which lists important new books and periodicals which have appeared during the year.

The subject matter of the text has been prepared by thirty-five of England's leading

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This large, paper-bound monograph with many roentgenograms and other illustrations, printed on excellent paper, presents an interesting and careful study of the problem.

reexamined. The tabulation of results was complicated by the presence of other lesions in the knees treated. In general the results were encouraging. Osteophyte formation was a frequent sequel.—*Walter P. Blount, M.D., Milwaukee, Wisconsin.*

**POLYOSTOTIC FIBROUS DYSPLASIA.** Torfinn Denstad. *Acta Radiologica*, XXI, 143, Apr. 1940.

The author describes the case of a woman aged eighteen, who presented herself, complaining of pain and limp ten years after a fracture of the left femur. After briefly reviewing the differential diagnosis, eliminating simple bone cyst, giant-cell tumor, and generalized osteitis fibrosa cystica, the author inclines to the opinion that his case belongs to the category designated by Lichtenstein as "polyostotic fibrous dysplasia".

The lesion is believed to represent a congenital anomaly of skeletal development. Symptomatically, the disease is characterized by pain, limp, and deformity, which develop during the childhood and adolescence of women. Pathological fracture is common. Roentgenographically, rarefaction of the affected bones, with thinning and expansion of the cortex, is typical. The calcium and phosphatase content of the blood are unchanged. At operation, the marrow cavity is frequently filled by a relatively avascular grayish-white tissue of spongy or elastic consistency. Operation does not appear to have any therapeutic significance. Since the activity of the lesion decreases with advancing years, the most rational treatment consists in prophylaxis against fracture.—*Henry Milch, M.D., New York, N. Y.*

**DIAGNOSIS AND ROENTGEN TREATMENT OF CERTAIN FORMS OF LUMBAGO.** Chr. I. Baastrup. *Acta Radiologica*, XXI, 151, Apr. 1940.

The author calls attention to the fact that the interspinous space is normally greater anteriorly than posteriorly. While this may vary physiologically, contact of the tips of the spinous process with loss of the interspinous tissues may lead to a severe form of backache. This usually occurs in hyperextension and may be associated with a number of different conditions. Acute flexion may lead to the same symptoms as a result of the tearing of the interspinous ligaments. This condition he designated as osteo-arthritis processus spinosi.

In the acute cases, the pain is usually localized over the interspinous space, but it may be found in the paraspinal areas. Treatment consists of heat, rest, and sedation. In more severe cases, novocain injection frequently affords relief.

In the chronic cases, roentgenotherapy is frequently very efficacious. The details of the therapy are given. In brief, the individual is given 300 roentgen units. This may be repeated twice at intervals of six weeks. If this is ineffective, another series of two or three treatments, at six-week intervals, is given. Of a total of sixteen men, twelve showed improvement; among twenty-seven women, twenty-one were improved. In most cases the symptoms, of long duration, were relieved after a single exposure. The effect may be only temporary and the patient may require renewed roentgenotherapy upon recurrence of the symptoms.—*Henry Milch, M.D., New York, N. Y.*

**ARTHROGRAPHY AND ROENTGENOGRAPHY IN RUPTURES OF THE TENDONS OF THE SHOULDER JOINT.** Knut Lindblom. *Acta Radiologica*, XX, 548, 1939.

The author stresses the fact that in his series none of the clinical signs described by Codman, Palmer, and others proved to be pathognomonic of ruptures of the musculotendinous cuff about the shoulder joint. On the other hand, arthrography of the shoulder joint has proven an accurate diagnostic method.

Arthrography is performed by the intra-articular injection of six cubic centimeters of a thirty-five per cent. solution of perabrodil mixed with one cubic centimeter of novocain, after preliminary novocain anaesthesia. Roentgenograms are made immediately

in a series of four positions, which the author describes and illustrates. The interpretation of the normal roentgenogram in these different positions is contrasted with roentgenograms of clinically proven cases of ruptures of the various muscles about the shoulder joint.—*Henry Milch, M.D., New York, N. Y.*

**DETERMINATION OF SERUM "ACID" PHOSPHATASE ACTIVITY IN DIFFERENTIATING SKELETAL METASTASES SECONDARY TO PROSTATIC CARCINOMA FROM PAGET'S DISEASE OF BONE.** Alexander B. Gutman, Ethel Benedict Gutman, and John N. Robinson. *The American Journal of Cancer*, XXXVIII, 103, Jan. 1940.

The authors note that roentgenographic differentiation between osteitis deformans and skeletal metastases from prostatic carcinoma is occasionally impossible. The present study emphasizes the importance of determining the serum acid phosphatase activity as an aid in differential diagnosis.

Determinations were made by the method of King and Armstrong at a hydrogen-ion content of 4.8, and by the method of Bodansky in estimating alkaline phosphatase activity.

Most cases of prostatic carcinoma with bone involvement show serum acid phosphatase values greater than three units per 100 cubic centimeters. On the other hand, all but five of more than 200 control patients with diseases other than metastatic carcinoma of the prostate or Paget's disease were found to have serum acid phosphatase values of less than three units per 100 cubic centimeters.

The acid and alkaline phosphatase activity of the serum in thirty-two cases of Paget's disease is recorded in the present study. Six of the most advanced cases, with serum alkaline phosphatase levels of over seventy Bodansky units per 100 cubic centimeters of serum, were found to have serum acid phosphatase levels of over three units per 100 cubic centimeters; in the remaining twenty-six cases, normal values were obtained.

The author concludes that the determination of serum acid phosphatase activity appears to be applicable to the differentiation of Paget's disease from bone metastases secondary to carcinoma of the prostate.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

**THE OPERATIVE LENGTHENING OF THE TIBIA AND FIBULA. A PRELIMINARY REPORT ON THE FURTHER DEVELOPMENT OF THE PRINCIPLES AND TECHNIC.** Leroy C. Abbott and John B. deC. M. Saunders. *Annals of Surgery*, CX, 961, 1939.

The authors review their earlier experiences in operative lengthening of the tibia and fibula, which was begun in 1924. They refer to the difficulties and complications encountered and mention the trend of some surgeons toward less radical procedures such as shortening of the sound leg by fusion of the epiphyses. However, there is a limited group of cases in which bone lengthening is definitely indicated; consequently the authors have conducted further studies with a view to reducing the chances of complications from this procedure.

To a large extent these complications result from a failure of the soft parts to lengthen proportionally with the bones. In order to determine the exact relationship of the deep fascia, intermuscular septa, and interosseous membrane to the tibia and the fibula, as well as the relationship of the muscles to these structures, the authors carried out many anatomical dissections.

As a result of these studies, they developed a technique of operation based on new principles. This technique involves a complete division of the deep fascia of the leg, the intermuscular septa, and the interosseous membrane, as well as the freeing of all the important blood vessels and nerves at the upper portion of the leg.

The chief features of the operation are:

1. Special osteotomies to retain the maximum portion of the origin of the muscles which pass from the leg to the foot.

2. Incisions to provide for freeing the blood vessels and nerves from their points of fixation.

3. Preservation of the nutrient vessels of the tibia and the fibula and a minimum reflection of the periosteum of these bones.

A new apparatus has been developed which gives better control over the fragments and decreases the chances of infection.

Seven cases in which the new technique was used are reported, along with critical comment on the operative technique and postoperative course in each case.

The authors emphasize the fact that the operation of bone-lengthening is and always will be a major undertaking with the possibility of serious complications. They feel that with more study and experience a less radical procedure will be developed to carry out the same objectives.—*O. B. Bolibaugh, M.D., San Francisco, California.*

**A CLINICAL CONSIDERATION OF THE METHODS OF EQUALIZING LEG LENGTH.** Philip D. Wilson and T. Campbell Thompson. *Annals of Surgery*, CX, 992, 1939.

This paper presents a very complete survey of the subject. Inequality of leg length has always been regarded as a disgraceful and crippling condition. The unfortunate victims suffer from a psychological as well as a physical handicap. In selecting cases for operation, sound surgical judgment and not sentiment must be the deciding factor.

The surgical approach to this subject is discussed by the authors under the following classification:

I. Changing the rate of growth:

(1) Stimulation of growth in the shorter extremity.

(a) Local stimulation of bone growth.

(b) Lumbar sympathectomy.

II. Surgical reconstruction.

(1) Bone lengthening of the shorter extremity.

(2) Bone shortening of the longer extremity.

Illustrative cases, showing results from the various methods, are reported. The advantages and disadvantages are presented in detail.

The various factors to be taken into consideration in selecting the type of procedure are emphasized. Their conclusions can be summed up briefly as follows:

1. Local stimulation is as yet of no clinical value.

2. Improvement cannot be assured from lumbar sympathectomy. The greatest gain that can be expected is about one inch.

3. Epiphyseal arrest is a relatively minor procedure. Careful calculation must be made to determine at what age the operation should be done. Complete fusion is necessary to prevent deformity from unequal growth. This operation is applicable only during the growing period.

4. Leg lengthening is a formidable procedure, frequently attended by serious complications, and should not be attempted in severely paralyzed or atrophic extremities. It should be done only in cases in which the patients are too old for epiphyseal arrest or are unwilling to sacrifice height by shortening the longer leg.

5. Leg shortening has the disadvantage that it must be done on the longer and usually sound leg. It is relatively simple and much safer than bone lengthening. This procedure gives a better functional result than leg lengthening.—*O. B. Bolibaugh, M.D., San Francisco, California.*

**BLOOD-BORNE PYOGENIC INFECTIONS OF BONES AND JOINTS.** Fenwick Beekman and John E. Sullivan. *Annals of Surgery*, III, 292, Feb. 1940.

The authors point out that our conception of acute osteomyelitis has undergone constant changes during our lifetime.

Thirty years ago the disease was considered a local condition and was treated by radical resection of the involved bone. These drastic shock-producing operations, if not hastening death, often resulted in a crippled and deformed limb or an amputation.

The significance of blood-stream infection in acute osteomyelitis was not appreciated by earlier writers.

The blood-stream infection may be transitory or persistent, in the latter case it produces death of the patient. In the former case, treatment need be directed only at the local condition.

The authors quote statistics which show the mortality is not due to osteomyelitis but to the preceding blood-stream infection which may cause death through septicaemia or pyaemia. Therefore, treatment should be directed against the underlying blood-stream infection.

Twenty-one case histories from the Children's Surgical Service of Bellevue Hospital are presented with comments. From their studies, the authors arrived at the following conclusions: (1) Death results from septicaemia or pyaemia and is not due to the lesions in bones or joints. (2) *Streptococcus* septicaemia behaves differently from *staphylococcus* septicaemia, as shown by local and general manifestations. (3) Every attempt should be made to recognize the organism before treatment is begun. (4) More attention should be paid to the general condition of the patient before operation on the local condition is undertaken. The normal physiological balance of the body should be established by use of intravenous saline and glucose solutions, and by transfusions. (5) Local lesions should not be drained by incision until an abscess is formed or frank pus is found to be present. In pyarthrosis, operation to relieve tension is indicated. Lesions due to *staphylococcus* should be drained as soon as the patient's bodily condition warrants it. Those due to *streptococcus* may be drained when the purulent exudate has formed. (6) In the treatment of acute osteomyelitis and pyarthrosis, complete immobilization of the extremity with infrequent dressings has proved of benefit. (7) By employing the above methods, decrease in mortality has been effected. (8) Far better functional results have been obtained in pyarthrosis by use of the Orr method.—

O. B. Bolibaugh, M.D., San Francisco, California.

THE TREATMENT OF COMPOUND FRACTURES OF THE LONG BONES. James H. Heyl. *Annals of Surgery*, III, 470, Mar. 1940.

This paper is based on a study of all the compound fractures of the extremities which were originally treated at the Beekman Street Hospital from 1925 to 1936, inclusive. There were 128 patients.

This paper is somewhat unique in that it is based upon an analysis of mistakes and failures rather than upon good results.

Résumés of the following groups of cases are presented: (1) Thirteen patients died within thirty-six hours after admission without operation. (2) Nine patients died within twenty-four hours after admission after débridement. (3) Five patients had immediate amputation. (4) Eleven patients had late amputation. (5) Résumé of late fatalities.

There were twenty-six deaths in the series, or a total mortality of 20.3 per cent. Excluding the thirteen fatalities which occurred within thirty-six hours, the mortality was 11.3 per cent. Sixteen patients were subjected to amputations. There were nine anaerobic infections in the series.

The following points are emphasized in the conclusions: Traction should be applied in all compound fractures for transportation. A careful examination should be made on admission to determine the complicating conditions. Shock must be combatted before operative procedures are undertaken. Débridement should be performed within six hours of the injury or not at all. Reduction and immobilization should be undertaken early. Late reductions after infection is present are contra-indicated. Closure of wound with or without débridement should be exceptional. Amputations are necessary for

impaired circulation or spreading infection.—*O. B. Bolibaugh, M.D., San Francisco, California.*

**SPECIFIC OSTEOMYELITIS (SYPHILIS).** M. G. Ramachander. *The Antiseptic*, XXXVI, 1071, Nov. 1939.

This is the report of a case of specific syphilitic osteomyelitis in a four-year-old boy. The lesion involved the left tibia and fibula and the right humerus. The tibia suppurated and required incision and drainage.

Röntgenogram showed extensive involvement of the periosteum and patchy destruction of the cortex and medulla. There was no bone sequestration. Both parents had a history of syphilis, but the child showed no other signs of congenital syphilis. His convalescence was expedited by treatment with iodide and mercury.—*Robert M. Green, M.D., Boston, Massachusetts.*

**HEILUNGSERGEBNISSE VON HALLUX VALGUS-OPERATIONEN** (End Results of Hallux Valgus Operations). Ewald Fröhlich. *Archiv für orthopädische und Unfall-Chirurgie*, XXXIX, 624, 1939.

The author, working in Hohmann's Clinic, reports on sixty-six cases operated upon by Hohmann's method with occasional modifications, and ten cases operated upon by Brandes' technique.

Hohmann attacks the spreading of the forefoot by osteotomizing the neck of the first metatarsal and by displacing the head fragment laterally on the metatarsal shaft, at the same time rotating it medially and plantarward. At times the exostosis is chiselled off. Occasionally the lateral soft tissues must be divided to straighten the first toe. He then strips the soft tissues from the shaft of the first metatarsal sufficiently to mobilize it and forces it manually toward the second metatarsal (although he makes no provision for keeping it there). In one case, a corresponding procedure was performed in the area of the fifth toe.

Brandes resects two-thirds of the proximal portion of the basal phalanx of the great toe. The author prefers to resect but one-half. Usually the exostosis was simultaneously removed. The operation was performed when arthritic changes in the metatarsophalangeal joint made it inadvisable to employ the Hohmann procedure.

On the whole, the author was satisfied with the results of the Hohmann operation when the technique was followed accurately. Surgery on the joint itself necessitated longer after-care to restore adequate motion. Weight-bearing was not permitted for the first four weeks. Attempts to tighten the spread forefoot in four cases failed.—*Joseph E. Milgram, M.D., Brooklyn, New York.*

**ZUR BLUTIGEN BEHANDLUNG SCHLECHT STEHENDER KNÖCHELBRÜCHE** (Operative Treatment of Malaligned Ankle Fractures). v. Brandis. *Archiv für orthopädische und Unfall-Chirurgie*, XXXIX, 659, 1939.

Malaligned ankle fractures necessitated open operation in twelve of 280 fractures of the ankle occurring in an eight-year period. The difficulties revolve about the disruption of the fork of the ankle due to the rupture of the ligaments which hold the tibia to the fibula, displacement of the fibula, and displacement of the posterior fragmented portion of the tibial articular surface. Emphasizing the incidence of arthritic changes in these joints, the author at open operation insists on adequate exposure to permit accurate fixation with stainless-steel wire or, occasionally, with pins. He removes these as a rule in from six to eight weeks. In severe comminuted fractures of the fibula, a bone graft is used to restore the alignment of the fragments.—*Joseph E. Milgram, M.D., Brooklyn, New York.*

KNOCHENBRÜCHE UND SCHWANGERSCHAFT (UNTER BESONDERER BERÜCKSICHTIGUNG DER BECKENBRÜCHE). [Fractures and Pregnancy (with Especial Regard to Fractures of the Pelvis).] J. Lampert. *Archiv für orthopädische und Unfall-Chirurgie*, XXXIX, 675, 1939.

The author adds four cases of fractures occurring during pregnancy to the rather small number appearing in the literature. Three were pelvic fractures. In these, as in the reported cases, union was prolonged past the usual dates. In one of his cases, a large bony exostosis existed on the pubis, the consequence of a fracture sustained four months before the patient became pregnant. During the nine months of the succeeding pregnancy, the exostosis was spontaneously absorbed, and a normal delivery ensued.

The author agrees with the opinions expressed in the literature that bony union in maternal fractures is delayed during the first and middle thirds of gestation. During the last three months, rapid bone formation is noted.—*Joseph E. Milgram, M.D., Brooklyn, New York.*

LAS FRACTURAS DE LA EMINENCIA CAPITATA DEL HUMERO (Fractures of the Capitellum of the Humerus). Oscar R. Maróttoli. *Boletines de la Sociedad de Cirugía de Rosario*, VI, 459. Nov. 1939.

The lesion known as fracture of the capitellum of the humerus is one in which the fracture involves that portion of the external condyle of the humerus which projects outward and forward to articulate with the upper end of the radius. This fracture has received a good deal of attention and discussion in times past and the author goes into the history of this lesion in some detail. While this fracture is relatively rare in the ordinary surgeon's private practice several large series of cases have been reported and these are mentioned. His own series consists of four cases or 3.47 per cent. of the 115 fractures of the elbow which he encountered. The fractures are divided into two distinct classifications depending upon the location of the fracture line. The first class involves simply the tip of the external condyle, while the second class includes those with an extensive fracture extending down into the trochlear portion of the joint. In the author's series of four cases, three were of the second type. Without exception, the displaced fragment underwent some rotation. The rotation was quite variable, but either ninety or 180 degrees of forward rotation was often found. In general he concludes that in those cases in which the rotation is less than ninety degrees a closed reduction may be done with an expectation of good results, while in those cases where the rotation is over ninety degrees open reduction is usually necessary. He stresses, however, the importance of individualizing each case before deciding the type of treatment to use. The author emphasizes the importance of looking for other fractures in connection with the fracture of the capitellum, because they are especially common at the proximal end of the radius in connection with this lesion. Better anatomical reposition and better end results can usually be obtained by surgical treatment. The author presents his four cases in detail with roentgenograms illustrating each case.—*Louis W. Breck, M.D., El Paso, Texas.*

COMPRESSION FRACTURES OF THE OS CALCIS. Gordon Murray. *The Canadian Medical Association Journal*, XLII, 422, May 1940.

The type of fracture where the chief deformity is an impaction of a fragment including the articular surface of the os calcis into the lower fragment of this bone has presented many difficulties in reduction. It has been the author's experience, in several of these cases, that skeletal traction by the Böhler method or manipulation with traction and pounding did not elevate this fragment. It was planned, therefore, to elevate the fragment by open operation and to support it in position by bone grafts.

A lateral incision was used and the fragment was elevated with osteotomes. Two tibial grafts were cut, half an inch in thickness at the posterior ends and tapering off to



one-sixteenth of an inch anteriorly. The grafts were placed longitudinally in some cases and transversely in others.

Two cases are reported with roentgenograms. One patient returned to the work of a laborer four and a half months after operation, and at the end of a year had no deformity or disability. The other returned to work five months after operation, and at the end of a year and a half had no disability.

The author concludes that, while there is only a small percentage of cases of fractured os calcis of this type, they present a problem which has not been solved satisfactorily by other methods of treatment. In these cases open reduction with elevation of the fragment and insertion of bone grafts appeared to give satisfactory anatomical and functional results.—*F. R. Wilkinson, M.D., Toronto, Ontario.*

**FRACTURES OF THE MANDIBLE.** Stuart Gordon. *The Canadian Medical Association Journal*, XLII, 521, June 1940.

Forty-three cases of fracture of the mandible are discussed and a new modification of an old method of treatment is described.

Block anaesthesia of the inferior dental nerve with 2 per cent. novocain was used in sixteen cases, fifteen were done without any anaesthetic, five with avertin and nitrous oxide, and five with nitrous oxide. Avertin was the least satisfactory.

Various methods of wiring the teeth are described, including band wires and circumferential wires. The author's modification consists of passing a length of 28-gauge, stainless-steel wire between two molars or bicuspid and then in and out between the teeth until a corresponding tooth on the opposite side is included. In each instance a loop is formed in the wire where it lies on the buccal surface of a tooth. A mechanical looper has been devised which forms loops identical in size, shape, and length; this is illustrated. Cross ties of waxed silk are used. Fractures a short distance in front of the angle and with the posterior fragment edentulous are treated by passing a stainless-steel wire through a hole drilled near the angle of the mandible. Traction is obtained by fastening this wire with a piece of heavy elastic to a jury-mast extending down from a plaster head-piece. Extraction of a tooth lying in the line of fracture is not advised unless the tooth be dirty.

Complications in this series were relatively rare. Thirty-five obtained an immediate good result from treatment. One patient died of meningitis. The details of the less favorable results are given.—*F. R. Wilkinson, M.D., Toronto, Ontario.*

**STAPHYLOCOCCUS SEPTICEMIA WITH SEPTIC ARTHRITIS OF THE KNEE TREATED WITH SULFAPYRIDINE.** REPORT OF A CASE. J. I. Kendrick. *Cleveland Clinic Quarterly*, VII, 35, Jan. 1940.

Kendrick reports the favorable treatment of a case of septic arthritis of the knee joint by the oral administration of sulfapyridine and by multiple aspirations and irrigations of the joint. The blood and joint fluid were positive for staphylococcus aureus.

The patient, a boy, fourteen years of age, was seen five days after onset of pain following trauma to the knee. His temperature on admission was 103 degrees. The knee was maintained in flexion, with acute tenderness over the medial aspect of the joint, increase in joint fluid, and distention of the quadriceps pouch and periarticular thickening. Roentgenographic examination of the bones showed no pathological changes. The white blood count was 8050. On aspiration of the knee, a thick, greenish, purulent fluid was obtained, which contained many white blood cells, but smear and culture were negative for bacteria. The blood culture on admission was positive for staphylococcus aureus. The knee was again aspirated three days later. Culture of this fluid was positive for staphylococcus aureus.

A transfusion of 500 cubic centimeters of blood was given, and sulfanilamide was administered, but the septic temperature continued. On the fifth day sulfanilamide was discontinued, and sulfapyridine was started, after which the temperature gradually

subsided. The joint was aspirated eight times at intervals of from two to three days and irrigated with from 500 to 1,000 cubic centimeters of normal saline. Five days after sulfapyridine was started, the temperature was normal.

The patient left the hospital on the twenty-eighth day with full range of motion and no tenderness. Follow-up two months later showed normal motion, no periarticular changes, and no areas of tenderness.—*Frederic W. Ilfeld, M.D., Los Angeles, California.*

**FRAGILITAS OSSEUM. BRITTLE BONES AND BLUE SCLERA. HEREDITARY MESENCHYME HYPOPLASIA.** B. H. Nichols. *Cleveland Clinic Quarterly*, VII, 58, Jan. 1940.

Nichols reports a case presenting a mixed picture of fragilitas osseum, osteitis fibrosa cystica, and Paget's disease. The author believes that this case supports the theory that these diseases have a general relative etiology not due to parathyroid disease.

The patient was a man, thirty-one years of age. He had been a normal child until seven and one-half years of age, when the skull became abnormal in shape. There had been a series of fractures, beginning at the age of seventeen years and continuing until twenty-four years of age. He was poorly developed and had blue sclera. The entire cranium was markedly enlarged. There were bony exostoses of the canal of the left ear with diminished hearing. The preoperative blood calcium was 9.6 to 13 milligrams; the phosphorus was 1 to 3 milligrams; the phosphatase was five times the normal content. At operation one parathyroid gland, two and one-half times the normal size, was removed; the remaining parathyroids were normal. Histological examination revealed normal parathyroid tissue.

Fourteen months after exploration, the patient reported that he was well, but seven months later a large cyst developed in the left femur. The calcium at that time was 9.3 milligrams and the phosphorus was 2.7 milligrams. The following year exploration of the parathyroids again revealed no abnormality. The serum calcium was 9.5 to 12.5 milligrams; the phosphorus, 2.9 to 3.4 milligrams; the phosphatase, 21.5 to 28.2 milligrams (Bodansky); and the basal metabolism, plus 7. There were cystic areas in both iliac bones, in the wings, and in the sacral portions, and large cystic areas were present in the ischium and pubes. The patient continued to have painless fractures from slight trauma. He died at another hospital, where unfortunately no necropsy was performed.

—*Frederic W. Ilfeld, M.D., Los Angeles, California.*

**REGENERATION OF EPIPHYSEAL CENTERS OF OSSIFICATION FOLLOWING DESTRUCTION BY PYOGENIC OR TUBERCULOUS INFECTION: REPORT OF FIVE CASES.** Samuel W. Banks, William Krigsten, and Edward L. Compere. *The Journal of the American Medical Association*, CXIV, 23, Jan. 6, 1940.

This article is based on a study of five cases in which regeneration of a completely or partially destroyed epiphysis was known to have existed. In four cases the epiphysitis was caused by pyogenic organisms and in the fifth, by tuberculosis.

These cases illustrate the ability of centers of ossification to regenerate after a severe infectious process. This capacity depends on the amount of cartilage that remains. Varying degrees of longitudinal bone growth were observed following an acute, infectious epiphysitis, indicating that the epiphyseal plate may remain viable, despite the fact that the entire adjacent epiphysis has been destroyed. The youngest patient was seventeen days old, and the oldest was seven and one-half years of age.—*Henry H. Beckering, M.D., Dallas, Texas.*

**SYMPATHICOBLASTOMA.** Fremont A. Chandler and John R. Norcross. *The Journal of the American Medical Association*, CXIV, 112, Jan. 13, 1940.

Tumors of the sympathetic nervous system are probably seen most frequently by the neuropathologist and the neurosurgeon. Occasionally the paediatrician, the internist, the abdominal surgeon, and the urologist encounter them. They are rarely observed by

the orthopaedic surgeon, but must be considered before making the final diagnosis in certain lesions of the spine.

By far the greater majority of the cases of the neoplasm that have been reported involve the medullary portion of the adrenal gland. They may occur, however, at various locations within the body, producing a multiplicity of symptoms.

"A sympathicoblastoma is a completely undifferentiated malignant tumor which takes its origin from embryonal cells of the sympathetic nervous system. The parent cell of the sympathetic primordia is the sympathogonia. This is a completely undifferentiated spherical cell with a densely staining nucleus and little cytoplasm. This develops into a larger cell, the sympathoblast, which is polygonal and has a considerable amount of cytoplasm in which fibrils may be seen. The cytoplasm of these cells may be prolonged into filamentous processes." The microscopic appearance of these tumors depends on the type of cell which predominates. If most of the cells are sympathogonia, the tissue has an appearance similar to that of a sarcoma, with masses of densely packed round cells containing little cytoplasm. Usually some sympathoblasts are present, and one or more rows of these cells may be formed about a central mass of fine fibrils, forming the characteristic rosette.

Four cases seen in children, ranging from eighteen months to nine years, are reported. In one, the tumor took origin in the spinal canal and migrated through the intervertebral foramen into the thoracic cavity. In another, an extradural tumor was found within the canal in the upper thoracic region. In a third, a biopsy from cervical glands was positive, and roentgenographic examination revealed a mediastinal mass. A positive cervical-gland biopsy in the fourth case was associated with a mass in the abdomen just to the left of the spine at the level of the second, third, and fourth lumbar vertebrae. All of these children presented neurological symptoms, and death occurred within from one to two years.—*Herschel Penn, M.D., Knoxville, Tennessee.*

THE DIAGNOSIS AND TREATMENT OF SLIPPED EPIPHYSES. Ralph K. Ghormley and Robert D. Fairchild. *The Journal of the American Medical Association*, CXIV, 229, Jan. 20, 1940.

In treating slipping upper femoral epiphyses, consideration must be given not only to the immediate result—that is, relief from pain and disability and correction of deformity—but also to the ultimate result, which can be estimated only after the patient has reached the age of fifty or sixty years. It is the opinion of the authors that, in spite of some apparently not too good immediate results from modern methods of treatment, on the whole the results in these cases from thirty to forty years hence will justify this treatment in most instances.

A review of the literature relative to the etiology of slipped epiphysis is made, and most of the various hypotheses presented can be placed in one of three grades: (1) mechanical or traumatic, (2) infectious, and (3) endocrine. The idea of trauma as the main if not the sole cause seems to the authors the most reasonable. With a pre-existing increase in the inclination of the epiphyseal line and obviously increased rapidity of growth at the age of adolescence, a slight or moderately severe trauma may well set up the slipping process which leads to the condition.

Diagnosis should be made in the very earliest stage of slipping, called by some the "preslip" stage, and any adolescent presenting himself with a slight limp or painful hip should be regarded with suspicion and should have careful physical and roentgenographic examinations.

The numerous methods of treatment which have been advocated include manipulation and cast, traction on a Jones frame, prolonged fixation on a Jones frame, rest, open reduction with or without internal fixation, drilling of the head of the femur and epiphyseal line, impaction with the Cotton mallet, insertion of a Smith-Petersen nail, skeletal traction and plaster boots, manipulation and internal rotation. The authors summarize the appropriate treatment in the various stages as follows:

*Stage 1—Early Slipping:* Conservative measures should be used; weight-bearing by use of crutches, with or without a walking caliper splint and a high sole on the shoe of the sound leg, should be discontinued.

*Stage 2-A—Gradual Slipping:* During this stage the epiphysis is not completely separated and the displacement cannot be reduced by manipulation without danger of damaging the epiphysis, the epiphyseal line, and the circulation in the ligamentum teres. Open operation with osteotomy is the treatment of choice.

*Stage 2-B—Acute Slipping Superimposed on Gradual Slipping:* Here the head of the femur is usually loose and the displacement can be reduced by gentle manipulation, if treatment is not delayed too long after the complete separation has taken place. If one is not sure whether or not the head is loose, an open reduction to replace the head is better than to risk damaging the head by rough manipulation.

*Stage 3—Complete Slipping of Long Standing:* Here an open reduction with replacement of the head of the femur, if possible, is the treatment of choice. If the epiphyseal line is closed, osteotomy through the neck to correct the external rotation and shortening of the leg is indicated. Adults are best treated by some form of arthrodesis, if pain is a prominent symptom, or by acetabuloplasty, if motion is to be preserved.

A review of the methods of treatment and end results in fifty-five cases seen at The Mayo Clinic during the fifteen-year period from January 1, 1922 to December 31, 1936 is presented.—*Herschel Penn, M.D., Knoxville, Tennessee.*

#### EXPERIENCE WITH COBRA VENOM IN THE ARTHRALGIAS AND RELATED CONDITIONS.

Otto Steinbrocker, George C. McEachern, Emanuel P. LaMotta, and Freeman Brooks. *The Journal of the American Medical Association*, CXIV, 318, Jan. 27, 1940.

A preliminary report on therapeutic experience with cobra toxin for relief of pain in arthritis, neuralgia, and related conditions is presented.

Intramuscular injections of two cubic centimeters or ten mouse units were given daily whenever possible for from five to ten days after an initial injection of one cubic centimeter (five mouse units) to ascertain tolerance. When subjective and objective improvement or the latter alone persisted during a period of three or four injections, the dose was reduced or the interval between injections was gradually lengthened, so that the patients received treatments three times, twice, and, finally, once a week. The sites of injection were alternated regularly between the deltoid areas and the upper outer gluteal quadrants. A control group was made available by the administration of physiological solution of sodium chloride in other patients. In some instances venom was substituted for saline after several weeks. The good effects of the snake extract were in no instance apparent before at least five injections had been administered, and usually from eight to ten treatments of the ten-unit doses were required for any benefit to be admitted or noticed. In almost every instance the benefit recorded referred to subjective relief.

Thirty-six control patients suffering arthralgias received injections of saline solution from two to five times a week. Seven (19.4 per cent.) showed slight to moderate symptomatic relief. Twenty-nine (80.6 per cent.) failed to respond. Of sixty-one patients treated with cobra venom, thirty-six (59.01 per cent.) were slightly to moderately benefited, while the condition of twenty-five (40.9 per cent.) was uninfluenced. Of fourteen patients with rheumatoid arthritis, nine received the control therapy of saline solution without relief; whereas of thirteen who were given cobra injections, eleven appeared to have slight to moderate improvement. Of twenty-four patients with osteo-arthritis, seventeen were given saline with slight to moderate benefit in four and without effect in thirteen. Of twenty-three patients with osteo-arthritis to whom venom was administered, seventeen derived slight to moderate improvement and six obtained no relief. Of fourteen patients with fibrositis, five were subjected to control therapy of saline with slight benefit in one and no effect in four. Among thirteen patients with fibrositis who were injected with the venom, only two showed slight to moderate improvement, while eleven reported that the symptoms were unchanged. There were thirteen patients with

neuralgia, of whom five received saline; two showed slight to moderate relief and three obtained no benefit. Twelve patients with neuralgic symptoms were given venom; six of these reported no effect, and the remaining six showed slight to moderate improvement.

It is the authors' opinion that "as an added comforting measure, to tide patients over an intractable period of treatment in acute or chronic arthralgia or neuralgia, cobra venom in certain cases appears to offer some supplementary analgesic effect."—*Herschel Penn, M.D., Knoxville, Tennessee.*

**CONGENITAL SYPHILITIC SYRINGOMYELIA WITH ARTHROPATHY OF ELBOW.** Peter G. Denker, and Foster Kennedy. *The Journal of the American Medical Association*, CXIV, 408, Feb. 3, 1940.

The authors report a case of this extremely rare condition in a negro boy, aged twelve, who was admitted to the neurological ward, complaining of weakness and numbness of the right leg. There had been no previous illness. A cast was applied, which caused a painless ulcer on the right foot. Repeated soaking of the foot in hot water resulted in a severe burn, which refused to heal promptly. A Wassermann test at this time revealed a four-plus reaction. Antiluetic treatment was started. A check of the family revealed a four-plus reaction to the Wassermann test in the father, one brother, and one sister.

Physical findings were negative except for sensory changes in the right side, consisting of complete loss of pain and temperature sensations; touch response was unchanged. These findings were most marked in two bands,—one from the third cervical to the sixth thoracic segments, the other from the fifth lumbar to the fourth sacral segments. A lumbar puncture showed pressure of 230 millimeters of water and complete block.

Injection of iodized oil through cisternal puncture showed arrest of the medium at the eighth thoracic and first lumbar vertebrae.

The patient received intensive antiluetic therapy faithfully for a year and a half, at which time he re-entered the hospital because of an atrophy of the right hand and enlargement of the right elbow. The elbow showed limited, painless motion, and no crepitation. A roentgenogram revealed destructive changes, as well as osteophytic new-growth areas. The articular surfaces were destroyed.

A lumbar puncture showed partial relief from the block. The Wassermann test was negative. The clinical impression was congenital syphilis, with pachymeningitis of the cord, secondary softening, and syringomyelia, cavity formation in the cervico-thoracic and lumbar regions, and arthropathy of the right elbow joint.

The process had been completely arrested by vigorous antiluetic treatment at the time of this report.

The authors direct the reader's attention to the facts that in patients with congenital syphilis, over two years of age, the percentage of positive Wassermann reactions is about 29. Few children reach adult life with neurosyphilis. Although congenital syphilis responds poorly to antiluetic therapy, neurosyphilitic processes can be arrested by intensive therapy.—*W. C. Peterson, M.D., Dallas, Texas.*

**PARALYSIS OF THE SERRATUS MAGNUS MUSCLE CAUSED BY LESIONS OF THE LONG THORACIC NERVE.** Darrell O. Overpeck and Ralph K. Ghormley. *The Journal of the American Medical Association*, CXIV, 1994, May 18, 1940.

Twenty-eight cases of paralysis of the serratus magnus muscle or of the long thoracic nerve are reported in this article. Trauma was the chief causative agent in this rather rare form of paralysis, of which the acute, the recurrent irritative, and the contributive are the various types. The symptoms of paralysis are pain in the region of the nerve, fatigue of or inability to elevate the arm, and the winging of the scapula. The function of the muscle is mainly to aid in fixing the scapula to the thorax when the arm is elevated anteriorly, and to rotate the scapula in abduction and forward elevation of the arm.

Treatment may be conservative or operative; the group treated by operative methods showed the poorest results. Bracing or splinting the arm and scapula with the serratus magnus at rest gives the best results when combined with physiotherapy. The prognosis for restoration of function is good in the majority of instances of the condition.

—Henry H. Beckering, M.D., St. Louis, Missouri.

**THE DIAGNOSIS OF NEUROPATHIC JOINT DISEASE (CHARCOT JOINT).** Ralph Soto-Hall and Keene O. Haldeman. *The Journal of the American Medical Association*, CXIV, 2076, May 25, 1910.

The usually accepted theory of pathogenesis attributes the development of the Charcot joint to the effect of a single injury or repeated injuries on an articulation which has lost its sensibility to pain. Underlying conditions may be tabes dorsalis, syringomyelia, injuries to the spinal cord, or leprosy. The characteristics, in the usual order of appearance, are: an enlargement of the joint from an effusion; a relaxation of its ligaments, leading to instability and deformity on weight-bearing; thinning of the articular cartilages, marginal fractures; sclerosis of subchondral bone in some areas and atrophy in other regions, loose bodies in the joint, and the formation of new bone outside the joint cavity. The most striking clinical observation is the absence of pain in the presence of such advanced pathological processes. Rigid pupils and absence of knee jerks are of greater importance in diagnosis than serological tests.

Of forty cases analyzed, sixteen demonstrated bilateral involvements. The average age at onset of symptoms was between forty-five and fifty years. The influence of trauma on the development of the arthropathy is seen in the ratio between the number of cases involving the lower extremities (fifty) and the number involving the upper extremities (seven). In eighteen cases the symptoms followed a severe injury. Bacteriological study of synovial fluid is indicated before surgery, since in cases showing positive cultures failure of fusion resulted.—Hirschel Penn, M.D., Knoxville, Tennessee.

**TREATMENT OF MUSCULAR DYSTROPHIES AND ALLIED CONDITIONS. PRELIMINARY REPORT ON USE OF VITAMIN E (WHEAT GERM OIL).** Simon Stone. *The Journal of the American Medical Association*, CXIV, 2187, June 1, 1940.

Stone reports the results of vitamin-E therapy in a group of seven cases (five of muscular dystrophy, one of muscle atrophy following anterior poliomyelitis, and one of muscle atrophy following multiple neuritis) treated in the Crippled Children's Clinics of the State of New Hampshire. The duration of treatment and observation ranged from eight to eighteen months. At present the wheat-germ oil is administered in a mixture with liquid vitamin-B complex. Each gram of the oil is standardized to contain two Evans-Burr units of vitamin E and the usual dose is four cubic centimeters from three to four times daily of one to seven parts suspension of wheat-germ oil in vitamin-B mixture.

Definite improvement was obtained in all the cases of dystrophy as evidenced by gain in muscle strength and displacement of dystrophic musculature by normally contracting muscle tissue.

In the cases of muscle atrophy following involvement of the nervous system, increase in amount of regeneration of muscle tissue became apparent after the addition of vitamin E to the vitamin-B complex the patients were receiving.

The addition of vitamin-B complex to vitamin E appeared to increase the therapeutic efficaciousness of the latter.—Brandon Carrell, M.D., Dallas, Texas.

**PHALANGIZATION OF THE FIRST METACARPAL AND ANATOMICAL REASONS FOR THE AUTHOR'S METHOD.** B. A. Shirokov. *Khirurgiya*, No. 7, 115, 1939.

Recognizing the usual difficulties which follow operations to mobilize the first metacarpal for substitution of a lost thumb, the author describes his method which is a modification of Albrecht's operation.

The author's operation is devised to increase the depth of the intermetacarpal space between the first and second metacarpals, to increase the distance between the heads of the first and second metacarpal, and to increase the mobility of the newly created thumb substitute.

The operation consists in the excision of the abductor pollicis brevis, opponens, and superficial head of the flexor pollicis brevis, as well as the transverse head of the adductor and the first dorsal interosseous. The proximal end of the pollicis longus is transplanted to the ulnar side of the head of the first metacarpal, or, in case of absence of the head, into the ulnar sesamoid. The redundant skin is removed and a plastic restitution of the remaining skin is performed to cover the mobilized first metacarpal.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

#### ANAEROBIC INFECTIONS IN THE WOUNDED DURING THE BATTLES AROUND LAKE KHASAN.

M. Akhoutine. *Khirurgiya*, No. 9, 3, 1939.

The battles of Lake Khasan took place in a swampy region, where there are no gardens or fertilized fields; where the population is very thin and there is no pollution; and where the soil could be called virgin. In spite of these facts, the anaerobic infection appeared from the first days of action. There were two periods of military activity. In the first, due to military circumstances, the wounded were removed with a delay of two to three days; these men showed an incidence of infection of 75 per cent. In the second period, the wounded were brought in within three to six hours after injury, and were submitted immediately to operative treatment, and, in certain instances, to injections of prophylactic gas-bacillus serum. Among the few cases, where the prophylactic serum was injected, the author observed rare cases of typical gas-bacillus infection. The author admits, however, that the number of patients treated by prophylactic serum is so small that no positive statements could be made on this point. His personal impression is that the basic prophylactic management of gas bacillus is a prompt and technically correct, primary surgical treatment of the wound. The author notes that of all the wounded, gas bacillus developed in about 80 per cent. of those with wounds of the lower extremity. It was absent in wounds of the head, face, and chest. It was most frequently observed in the explosive type of wounds. The incubation period was very short, eight to eighteen hours, mortality 16 per cent. The curative effect of the gas-bacillus serum was very insignificant, the surgical and general treatment proving of greater importance.

Remarkable results were obtained in the prevention of tetanus infections. There was not a single case of tetanus. This was due to the prophylactic injections of tetanus antitoxin, which were given to the army in the fall of 1937 and the spring of 1938.—

*Emanuel B. Kaplan, M.D., New York, N. Y.*

#### CONTRIBUTION TO THE PROBLEM OF THE BIOLOGICAL TREATMENT OF FRACTURES. S. I. Rizvach. *Khirurgiya*, No. 10, 96, 1939.

The author studied the healing of fractures treated by injections of a suspension of bone marrow into the site of the fracture. The bone marrow was obtained under aseptic conditions from the lower extremities of rabbits and from the long bones of freshly killed calves. The bone marrow was triturated with physiological salt solution with the addition of .25 per cent. of phenol. The suspension was injected into the site of experimentally produced closed and open fractures of the lower extremities of rabbits. The rabbits were divided into two groups. One group received the rabbit bone-marrow suspension, the other, the calf bone-marrow suspension. In each group several animals were left as controls with immobilization only, and several were treated by injections of physiological salt solution. Several roentgenographic examinations amplified by histological investigations proved to the author that the bone-marrow suspension produces a marked multiplication of bone cells and acts as a powerful specific agent inducing a speed-

ing up of callus formation with increased density and size of the callus.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

CONTRIBUTION TO THE PROBLEM OF TREATMENT OF FRACTURES OF THE FEMUR. J. M. Bass. *Khirurgiya*, No. 11, 121, 1939.

The material on which the report is based consists of sixty cases of closed fractures of the femur treated in one institution for a period of seven years. The author comes to the following conclusions: The treatment must follow the functional method, using skeletal traction for twenty to twenty-five days as a minimum. In old people fractures with joint involvement should be treated by skeletal traction followed by skin traction. Indications for osteosynthesis should be strictly analyzed, and osteosynthesis should be avoided as much as possible. In cases of recent malunion with six to eight centimeters of shortening (not older than six months) a closed refracture followed by traction may be substituted for the traumatic and rather dangerous operation of osteosynthesis.—

*Emanuel B. Kaplan, M.D., New York, N. Y.*

CLINICAL OBSERVATIONS ON FILLING INFECTED BONE CAVITIES WITH GLUTIN (CARPENTERS' BONE GLUE). L. Shkolnikov. *Khirurgiya*, No. 12, 92, 1939.

The treatment of bone cavities is difficult. The rigid walls of the bone have no tendency to contract as do the soft tissue cavities. The filling of the bone cavities is, therefore, important. The author reviews the various substances proposed for this procedure, and critically analyzes the disadvantages connected with their use. The author indicates the important factors to be considered in the choice of an adequate material as follows: good plasticity, good resorptive properties, ability to stimulate regeneration of surrounding tissues, absence of toxicity, biological nearness to the tissues of the recipient, absence of marked irritability to surrounding tissues, ease of sterilization, and availability of an inexpensive product.

Although no ideal substance could be proposed, the best material for filling was found to be bone glutin (carpenters' glue).

Successful preliminary animal experimentations were performed, and then this substance was used in twenty-six clinical cases, of which eighteen cases were chronic osteomyelitis and eight Brodie's abscess. The operation consisted in saucerization, and filling of the cavity with 33 per cent. of bone glutin, followed by suture of the wound and application of plaster-of-Paris immobilization.

The author claims primary union of bone in seventeen cases, and a much shortened period of hospitalization.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

FRACTURES OF NECK OF THE FEMUR AND CONVULSION THERAPY. William Gissane, Donald Blair, and B. K. Rank. *The Lancet*, I, 450, March 9, 1940.

The authors point out that although much has been written about fractures of the vertebral bodies in treatment with cardiazol (convulsion therapy), little attention has been paid to injuries in and around the hip joint. They found thirty reported cases of fracture of the neck of the femur in patients treated with convulsion therapy, in seven of which the fractures were bilateral. They report four cases, and advance the theory that fracture of the neck of the femur happens almost exclusively in bone that is atrophied from disuse or age. The average age of their four schizophrenic patients who sustained such fractures was forty-one. All had had prolonged institutional treatment for mental diseases,—nineteen, twenty-one, three, and three and one-half years respectively. They conclude: (1) Convulsion therapy should not be used in elderly patients, or in those who have had prolonged periods of inactivity; (2) After convulsion therapy the skeletal system should be examined as a routine, and roentgenographic examinations made if indicated; (3) Once a fracture has been diagnosed, the usual treatment for such fractures should be given.—*Lenox D. Baker, Durham, North Carolina.*



TRAUMATIC BACKACHE. Norman Little. *The Medical Journal of Australia*, II, 755, 1939.

Traumatic backache in patients is a constant worry to the average physician, because, in the majority of cases, the examiner is unable to find any external evidence of the condition. Following injury, the patient generally assumes a position of slight flexion of the lumbar spine with some rotation. A few days later he usually states that pain develops if he remains in one position for any length of time, but is relieved upon his changing position.

In addition to performing the usual back examination, the author emphasizes the head-flexion test, the knee-flexion test, and Gaenslen's test. The head-flexion test is done with the patient lying supine; the examiner places one hand beneath the occiput and lifts the patient's head, so that the chin approximates the sternum. The patient is completely relaxed, as the motion is entirely passive. If there is any bone lesion above the level of the sacrum, the patient will feel localized pain. The knee-flexion test is done with the patient prone and the leg flexed on the thigh. This test determines the genuineness of the symptoms, as rarely is this test negative if actual back injury is present.

Treatment in most cases consists simply in spinal manipulation under anaesthesia. The average disability in a series of 200 patients treated by manipulation was between four and five days. Before this method of treatment was instituted, the average period of disability was slightly over five weeks. In some cases support is given by appropriate adhesive strapping of the low back.

The author has appended a series of fourteen spinal manipulations by which he routinely treats low-back pain due to trauma.—*Harold M. Childress, M.D., Jamestown, New York.*

SOME OBSERVATIONS ON SCIATICA. Norman Little. *The Medical Journal of Australia*, II, 901, 1939.

Primary sciatica, in contrast to secondary sciatica, has a sudden onset of pain with paralysis occurring at the same time or shortly afterward. Local treatment consists in appropriate splinting and heat to the affected areas. Great relief from pain may be obtained from epidural injection of sixty cubic centimeters of 1-per-cent. novocain solution into the sacral canal. In late cases the nerve should be stretched with the patient under general anaesthesia. One should wait at least three months after an acute attack before manipulating, in order to avoid the formation of adhesions.

In treating secondary sciatica, many factors are involved. Often the physician, without knowing the actual etiology, treats and relieves the patient. The author classifies the etiological factors as static, arthritic, traumatic, osseous, nervous, and pelvic. If roentgenograms reveal no bone pathology, conservative treatment is employed first. This consists in removing foci of infection, correcting static errors, manipulating the spine as indicated, and administering massive doses of vitamin B<sub>1</sub>. A plaster jacket is used, if complete rest of the low-back muscles is desired.

If arthritis is present and progressive immobilization is essential, in traumatic cases dramatic results may be obtained from manipulations without anaesthesia.—*Harold M. Childress, M.D., Jamestown, New York.*

THE PROBLEM OF THE FOOT WITH SPECIAL REFERENCE TO THE CARE OF THE SOLDIER'S FOOT. S. Watson Smith. *Medical Press and Circular*, CCII, 410, Nov. 15, 1939.

The author discusses several of the more common pathological factors contributing to foot pain. He notes that 90 per cent. of the soldiers in the Great War were partially flatfooted.

He emphasizes that the following things are important in foot care for a soldier: The shoe should be large enough to allow proper broadening of the foot. A rubber heel should be on the shoe. The toenails should have adequate care and an antiseptic

powder should be sprinkled in the shoe. Hardening a soldier's foot may be done by a salve containing one drachm of formalin to the ounce of vaseline. Frequent change of socks is likewise a necessity. Adherence to these rules of foot care will increase the military efficiency of the army.—*Herbert E. Hipps, M.D., Marlin, Texas.*

**LIPIODOL VERSUS AIR AS AN AID IN DIAGNOSIS OF PROTRUSION OF INTERVERTEBRAL DISC.** S. N. Berens. *Northwest Medicine*, XXXIX, 160, May 1940.

The use of lipiodol in intraspinal injection has the advantage of rendering greater clearness of detail in the roentgenograms, but can be used only when operation is impending, as it must be fully removed as soon as possible. Gases may be used in making a diagnosis of hernia of the nucleus pulposus, or protrusion of the intervertebral discs. In such cases, overexposure at a rapid speed must be employed, or the use of a rotating anode tube at 300 milliamperes for one-half second. The author believes that oxygen intraspinal injection is best for diagnostic purposes.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

**VITALLIUM IN INTERNAL FIXATION IN BONE SURGERY.** J. Irving Tuell. *Northwest Medicine*, XXXIX, 163, May 1940.

The author finds that the use of this alloy, which consists of 65 per cent. cobalt, 30 per cent. chromium and 5 per cent. molybdenum, in plates, screws, etc., does not cause any irritation or absorption of bone; and may be left in indefinitely. There are no contra-indications to its use in recent or old ununited fractures, and he illustrates cases where reconstruction of malformations of old ununited fractures have yielded very good results through the use of vitallium plates.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

**DIAGNOSIS AND TREATMENT OF ACUTE OSTEOMYELITIS.** John F. LeCocq, *Northwest Medicine*, XXXIX, 171, May 1940.

In his discussion the author emphasizes the tendency of the bacteria to lodge in the venous channels next the epiphyseal lines, where the phagocytosis is least active. He has found that the use of neoarsphenamine is excellent in combatting the staphylococcic septicaemia. His dosage is the equivalent of 0.45 grams for the average adult. He suggests also the use of sulfamethylthiazol as being very promising.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

**LES MALADIES DES LIGATURES. MOYENS DE LES PRÉVENIR ET DE LES TRAITER** (Affections following Ligature, with Methods of Prevention and Treatment). René Leriche. *La Presse Médicale*, XLVIII, 41, Jan. 16, 1940.

In a truly stimulating article, Leriche calls attention to the effects of ligature of the larger arterial trunks. These effects are accomplished, not only through a mechanical shutting off of the blood stream, but, in large additional measure, by the action of a vasoconstricting reflex.

The anatomical basis for the action is found in the disposition of the sympathetic nerves lying in the arterial wall and particularly about the site of origin of collateral arteries. As early as 1917 Leriche showed that where an artery was ligated or thrombosed and where, in consequence, the extremity was cold and cyanotic, resection of the obliterated segment sufficed to bring about restoration of circulation. In Leriche's opinion this was accomplished by release of the vasomotor spasm and a dilatation of the collateral arterial branches. He has been able to show that where all the collaterals have not been destroyed, this was brought about by a reversal of blood flow in those collaterals which arise distal to the site of the arterial section.

Many of these collaterals constitute the muscular branches of distribution of the larger artery. Leriche calls attention to the fact that in debriding lacerated wounds, the

problem consists in estimating just how much to resect in order to prevent infection and how much to spare in order to avoid gangrene. Provided sufficient collaterals remain, their function can be preserved by release of the sympathetic spasm. This can be brought about by section of the ligatured vessel, by periarterial sympathectomy, by resection of the sympathetic ganglia, or by novocain infiltration of the main sympathetic ganglia. This novocainization must be repeated as often as necessary, until the collateral circulation is reestablished.

However, even though gangrene may be avoided by these means, and circulation sufficient to maintain nutrition of the resting tissue be obtained, the blood supply may not be adequate for muscular action. In such cases, gradual sclerosis of the tissues may occur, even long after the immediate vascular accident. Intermittent claudication, cyanosis of the limbs, trophic changes, and even muscular weakness and imbalance, are, in Leriche's opinion, the consequence of the disturbed vasomotor control, following the original ligation. Theoretically, ideal treatment would involve suture of the injured vessel. Since this is unsuccessful in a majority of cases, ligation must be performed, provided the means previously mentioned are employed as a prophylaxis against the ill effects of the sympathetic vasoconstrictor reflex.—*Henry Milch, M.D., New York, N. Y.*

LES ARTHRITES DES FILARIOSES (Filarial Arthritis). L. Déjou. *La Presse Médicale*, XLVIII, 203, Feb. 14, 1940.

Filarial arthritis occurs in two forms: dracunculosis and onchocercosis. The clinical picture of each of these infestations is clearly described. Each is due to a specific filaria, which can be recovered from the aspirated synovial fluid. In the aseptic cases of dracunculosis, these arthritides are painless, and bacteriological examination of the fluid is the only means of diagnosis. In the cases of onchocercosis, the clinical picture is usually more acute.

Unless secondary pyogenic infection takes place, the prognosis is usually good. The treatment consists in repeated aspirations. Where septic infection occurs, the treatment is similar to that for ordinary septic arthritis.—*Henry Milch, M.D., New York, N. Y.*

RÉFLEXIONS PRÉPARATOIRES A DES RECHERCHES EXPERIMENTALES SUR LE RÔLE DU SYMPATHIQUE EN PATHOLOGIE ARTICULAIRE (The Rôle of the Sympathetics in Articular Pathology). S. de Sèze, G. Guiot, and J. Serane. *La Presse Médicale*, XLVIII, 233, Feb. 28, 1940.

The authors subjected the splanchnic nerve to faradization. They observed that weak currents applied for a short time resulted in a mild endothelial swelling, hyperplasia of the reticulo-endothelial cells, and multiplication of fibrocytes. A more intense electric current led to a more marked vascular congestion and small petechial hemorrhages. Strong currents, applied for a longer time, produced oedema, congestion, hemorrhages and, microscopically, necrotic changes in lymphoid structures and the vessel walls.

Attention is called to the fact that these are the changes noted in connective tissues and characterize the pathological changes found in Still-Chauffard disease, the splenomegalic arthropathies, and in the joint manifestations of patients showing anaphylactic shock. The authors suggest that these, too, represent the effect of stimulation of the sympathetic nervous system. They are of the opinion that the joint is a connective-tissue space and that the signs of joint dysfunction are to be considered as due to a disturbance of the dynamic and trophic influence of the sympathetic nerves upon the reticulo-endothelial tissue of the joint.—*Henry Milch, M.D., New York, N. Y.*

SOBRE AS ANOMALIAS E LESÕES DOS SESAMOIDES DO GRANDE ARTELHO (On the Anomalies and Lesions of the Sesamoids of the Big Toe). Achilles de Araujo. *Revista Brasileira de Ortopedia e Traumatologia*, I, 203, Mar. 1940.

The author made an extensive study of the problem. The knowledge of lesions of the sesamoids dates from the discovery of roentgenography. In the pre-roentgeno-

graphic era various fantastic and mystic properties were ascribed to the sesamoids. The bibliography concerning the sesamoids, at present considerable, began to grow only since the time of Stieda. The author cites various statistical data concerning the incidence of sesamoid anomalies. In his own series of 296 roentgenograms, the incidence of anomalies is 4 per cent. A classification of the anomalies is given. In order of frequency seven types are described. Attention is called to the difficulties of differential diagnosis of various lesions of the sesamoids in comparison with sesamoid anomalies accompanied by pain in the metatarsophalangeal region of the big toe. A general survey of literature indicates that fractures of the sesamoids are very rare. In his own series of fractures and luxations, the author had seven cases; of these six were confined to the medial sesamoid (five affecting this sesamoid only and one associated with a fracture of the lateral sesamoid), and one was an isolated fracture of the lateral sesamoid. The right foot was more frequently involved than the left. The age ranges between 20 and 30 years. Direct injury is responsible for the fracture in eighty per cent. of cases. The indirect mechanism is hyperextension of the big toe with unopposed and rapid contraction of the short flexor, abductor and adductor of the toe, and is similar to the mechanism of fracture of the patella. The treatment is mostly conservative. In cases of protracted pain, extirpation of the sesamoid is indicated. In the author's series two cases were operated upon by this method and gave unexpected and early relief of pain. The author calls attention to medicolegal difficulties frequently presented in connection with affections of the sesamoids.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

OSTEOPETROSIS EN EL TERRITORIO DE LA PAMPA (Osteosclerosis in the Pampa Territory). N. Capizzano, J. Valotta y F. R. Megy. *La Revista de Medicina y Ciencias Afines*, Jan. 30, 1940.

This is a very interesting paper on the subject of osteosclerosis due to the ingestion of fluorine, which has a rather high incidence in several areas in central Argentina. The fluorine content of the water which produces the disease is usually 1.50 milligrams per thousand. The percentage of the population showing symptoms of the disease is approximately 9.09 in the areas described. The authors report some experimental work in which rabbits were given fluorine salt over a considerable period of time. The animals showed a generalized weakness and wasting associated with changes in the bones, teeth, endocrine glands, and particularly in the blood. The giving of larger doses experimentally produced acute symptoms which were much more severe than those usually seen clinically. The clinical picture, which varies according to the amount ingested and the stage of the disease, is described in detail. There can be a good deal of bone change with little or no clinical manifestations. The symptoms of chronic fluorine intoxication include generalized wasting and loss of weight, aching pains in the bones and joints, and particularly the marked changes in the teeth which are more familiar. In the article a large number of roentgenograms are reproduced which show very marked osteosclerosis. This process is particularly marked in the pelvis, spine, and ribs. There is little change in the long bones, but the upper half of the femur often shows the osteosclerosis to a marked extent. The authors call attention to the fact that, in a usual clinical case, such a marked osteosclerosis as is shown in their roentgenograms is the result of many years' duration of the disease.—*Louis W. Breck, M.D., El Paso, Texas.*

LA DÉVIATION CONGÉNITALE DES DOIGTS "EN COUP DE VENT" [Congenital Deviation of the Fingers "en coup de vent" (as if produced by a gust of wind)]. M. Boppe and P. Faugeron. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur*, XXVI, 547, Sept. 1939.

A case of a rare congenital deviation of the fingers is reported. The four fingers of each hand are deviated toward the ulnar side of the hand. They are flexed at the metacarpophalangeal joints and extended at the distal and proximal interphalangeal

joints. This type is found very seldom as a congenital deformity and has been reported by only four other authors since it was first described by Boix in 1897. A description of the hypotheses of deviation is given. The authors attempted to correct the deformity by severing the collateral ligaments of the metacarpophalangeal joints and performing a capsulotomy of these joints, and by additional cutting of the palmar aponeurosis and the interossei. Although the immediate result was satisfactory, the ultimate outcome was considered a failure. The authors conclude that the results of operative intervention are very instructive, as they show that in older patients the process involves all the soft structures, as well as the bones and joints of the hand, making surgical intervention useless. However, in very young children, the process involves only the soft tissues of the hand and the reconstruction of a more normal hand may result from operation on the soft tissue.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

LA SYNOSTOSE VERTÉBRALE POSTTÉTANIQUE CHEZ L'ADULTE (Posttetanic Vertebral Synostosis in the Adult). V. Climesco, P. Sarbu, and St. Roman. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur*, XXVI, 558, Sept. 1939.

A case of severe dorsolumbar kyphosis which followed an attack of tetanus is described by the authors. The case is unique in that a complete synostosis of the anterior parts of the bodies of the ninth, tenth, eleventh, and twelfth vertebrae was found. A review of literature is given and several explanations of the production of this pathological entity are cited. The authors consider that in their case the synostosis of the vertebrae was the result of a mechanical action produced by tetanic contractures which induced a partial atrophy of the intervertebral discs and a subsequent fusion of the segments of the vertebral bodies which were in direct contact. The action of the toxins, either direct or indirect, is considered of secondary importance.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

LA SCIATIQUE DITE BANALE, ESSENTIELLE OU RHUMATISMALE ET LE DISQUE LOMBO-SACRE (Sciatica, True or Arthritic, and the Lumbosacral Disc). S. de Sèze. *Revue du Rhumatisme*, VI, 986, 1939.

De Sèze reviews the various theories of essential sciatica: arthritis, injury to the sacro-iliac joint, changes in the posterior intervertebral articulation, injury with displacement of the intervertebral disc. The thesis is well defended that essential sciatica is commonly the result of a posterior displacement of the contents of the intervertebral discs, particularly those between the fourth and fifth lumbar vertebrae and at the lumbosacral joint. He shows first by anatomical data that this lesion can cause sciatica. This type of lesion can explain the usual history of the development of sciatica. It can account for all of the symptoms observed. The roentgenographic facts, usually with negative findings in the bones, fit this explanation of sciatica. Laboratory data obtained by lumbar puncture suggests a lesion of this type. This theory permits an explanation of the diverse evolution of sciatica. The lesion can be demonstrated at operation and cure follows the removal of pressure upon the nerve roots. No case reports of clinical data are given.—*John G. Kuhns, M.D., Boston, Massachusetts.*

CARENCE ALIMENTAIRE ET RHUMATISME CHRONIQUE (Dietary Deficiency and Chronic Rheumatism). Georges Mouriquand. *Revue du Rhumatisme*, VII, 107, 1940.

Mouriquand reports studies upon the relation of lack of vitamin C to chronic arthritis, which he has been pursuing since 1914. He differentiates between an acute lack of vitamin C and a chronic lack. These observations are made of the results of a chronic lack of vitamin C: After the acute state is past, if the patient lives, there is a gradual mobilization and deposition of calcium to the periphery of the bone and to the periosteal tissues (a condition called by Leriche and Policard a peripheralization of calcium). After 150

to 200 days the condition seems to remain stationary. Decalcification takes place at the same time in certain parts of the bone, particularly the femoral head. During this time there are no physical signs or symptoms. After about 200 days osteophytes can be seen in roentgenograms which the author considers periosteal lesions. In the more pronounced changes there was no evidence of repair following the giving of vitamins.—*John G. Kuhns, M.D., Boston, Massachusetts.*

**FRACTURES AND NECROSIS OF THE SEMILUNAR BONE AND THEIR IMPORTANCE IN INSURANCE PRACTICE.** Miroslav Jaroš. *Slovansky Sborník Ortopedický*, XIV, No. 3, 1939.

The series reported by the author embraces seven fractures of the semilunar, twenty cases of semilunar necrosis, and two cases of Köhler's disease of the semilunar bone. The primary bone necrosis is due to causes in the form of lesser or greater injuries to the trabeculae and the trabecular vessels. This idea is confirmed by the typical localization of the primary necrosis in places corresponding to the mechanical stresses. The author points to the lunatum necrosis which comes from working with compressed-air tools and also indicates that the general disposition, constitution, and avitaminosis, play a rôle in this condition. It is necessary to distinguish between semilunar bone fractures and semilunar necrosis. The latter often shows no symptoms and remains latent, but occasionally it becomes activated. In men who work with compressed-air tools the semilunar necrosis is an occupational condition with a functional loss of ten to twenty per cent. or even as high as thirty per cent.—*A. Steindler, M.D., Iowa City, Iowa.*

**PARATHYROID OSTEOSIS. REPORT OF A SEVERE CASE WITH SUCCESSFUL REMOVAL OF A LARGE PARATHYROID TUMOR.** James Vance, Jacob Rodge, and Louis W. Breck. *Southern Medical Journal*, XXXIII, 128, Feb. 1940.

Classification, pathology, symptoms, and treatment of parathyroid osteosis are discussed. There is a case report of a woman forty-seven years of age with a large parathyroid tumor. There were marked bone changes in both hips, and both femora were fractured. A large tumor one and one-half by one and one-fourth by one and one-fourth inches was removed successfully. Tetany developed. Large doses of intravenous calcium gluconate were given, and parathyroid hormone. After five months, fractures were uniting and bones recalcifying.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

**A STUDY OF ACUTE INFECTIOUS LESIONS OF THE INTERVERTEBRAL DISKS.** Ralph K. Ghormley, William H. Bickel, and Douglas D. Dickson. *Southern Medical Journal*, XXXIII, 347, Apr. 1940.

Cases have been reported following typhoid fever, streptococcus viridans blood-stream infections, osteomyelitis, pyogenic infections, and trauma. Symptoms: Fever may or may not be noted; pain in the spine; limitation of motion; and muscle spasm.

X-ray findings may be negative in the early stages, but later there is a narrowing of the intervertebral space, later proliferation of new bone along the margins of the vertebrae, and finally bone fusion may result. Brucella infections may cause a similar condition. Prognosis is usually good, but some mild symptoms may persist for a long time.

Treatment of the general condition is required, plus a close-fitting plaster jacket in mild hyperextension. This may be followed by a back brace or corset until the symptoms subside. Spinal fusion is seldom indicated.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

INJURIES ABOUT THE CARPOMETACARPAL JOINT OF THE THUMB. Ben L. Schoolfield. *Southern Medical Journal*, XXXIII, 354. Apr. 1940.

Posterior dislocation of this joint occurs after blows with the fist and such rough games as football and basketball. Persistent relaxation of the joint with pain and disability may result.

Adequate and early immobilization in a cast is advised. For cases in which disability persists a surgical operation for shortening the dorsal ligament is described and illustrated.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

THE LOCAL IMPLANTATION OF SULFANILAMIDE IN COMPOUND FRACTURES. J. Albert Key and Thomas H. Burford—*Southern Medical Journal*, XXXIII, 449, May 1940.

Various authors have reported the fact that sulfanilamide crystals placed in the wound of a compound fracture after débridement has greatly reduced the percentage of infections. The authors decided to see if the method of treatment delayed the healing of fractures in experimental animals. Fifteen rabbits were used. Symmetrical fractures were produced in both forelegs. The fractures in the right legs were packed with crystals of sulfanilamide, those in the left were not. The time of union, X-ray appearance, and microscopic sections showed that the sulfanilamide did not have any bad effects. Similar experiments were carried on in twelve fractures in dogs. Conclusions were that local implantation of sulfanilamide crystals in compound fractures not only tends to lessen the danger of infection, but does not perceptibly interfere with union of the soft parts of the bone. The wound must be cleaned and débrided in the usual careful way, preferably within twelve hours of the injury. The wound is then sprinkled with the crystals and closed. Of course the fracture is reduced and fixation maintained. If there is a large wound that cannot be closed the treatment is the same except that the open wound is covered with vaseline gauze and a plaster cast applied. This method has not been used in clean surgical operations, but if there is any reason to expect a possible contamination of the wound it would probably be good treatment to use the sulfanilamide crystals.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

THE USE OF THE WELL-LEG SPLINT IN TREATMENT OF INTERTROCHANTERIC FRACTURES OF THE FEMUR. W. C. Hunsucker and Douglas Jennings. *Southern Medicine and Surgery*, CII, 239, May 1940.

In the experience of the authors in a small community hospital, intertrochanteric fractures are eight times more common than intracapsular fractures.

The similarity of these fractures to the latter group in age, production of shock, and necessity for treatment are discussed. The various methods of treatment are described, and a description and discussion of the well-leg traction device is given. The dangers to note, and the postreduction care necessary in the patient's immediate recovery period, are discussed.

No ill effects were noted from immobilization of knee and ankle on either side. The patients may usually have the splint and plaster removed in eight weeks and by the end of the twelfth week may be allowed crutches. Normal walking is allowed by the sixteenth week.

In three years sixteen patients were treated by this method with uniformly good results.—*Herbert E. Hips, M.D., Marlin, Texas.*

REHABILITATION OF CONGENITAL SPASTIC PARALYSIS (LITTLE'S DISEASE). Wilfred C. Curphey. *Southwestern Medicine*, XXIV, 94, Mar. 1940.

Cerebral palsy is defined as an upper-motor-neuron lesion, affecting the cerebral motor centers, due to injury or disease. The classification of Phelps is quoted, and an explanation of the patient's behavior mechanism is made. It is estimated that there

are from forty to fifty spastics per 100,000 population. Seventy per cent. of these can be improved, 7 or 8 per cent. can be benefited by surgery; while 20 per cent. can be rehabilitated to occupy relatively normal places in the world. Less than 25 per cent. are mentally deficient. Pusitz estimates that from 25 to 50 per cent. are of average intelligence, from 5 to 10 per cent. are abnormally bright, and 10 per cent. or less are idiots or morons.

In the treatment, hospitalization is first necessary for study. Physiotherapy is the all-important method of treatment, and the first principle depends naturally on what the examination reveals. Sometimes relaxation is first in importance, and sometimes this is combined with equilibration. Aids to teaching relaxation are sedatives and warm baths, but these should not be relied on to the extent that the patient will become dependent on them. Treatment of the extremities should begin with the proximal joints and gradually extend to the more distal joints. Long periods of time are usually necessary, five years ordinarily being the minimum. Surgical indications are never immediate. They should never be resorted to until a preliminary period of training has been tried. Among the surgical procedures that are used, tenotomy is condemned, as the result is irreparable; tendon lengthening seldom produces permanent improvement. Novocain injection of nerve trunks is of value to decrease temporarily function in certain muscles for study of the patient's reactions. Alcohol injection of nerve trunks and the Stoffel operation are valuable aids to treatment.—*Herbert E. Hipps, M.D., Marlin, Texas.*

TUBERCULOSIS OF THE SPINE M. G. Rosenbaum. *Southwestern Medicine*, XXIV, 123, Apr. 1940

Vertebral tuberculosis is essentially a disease of childhood. It often occurs where there is a familial history of tuberculosis. The lower thoracic and upper lumbar regions are most often involved. More than one lesion may be present. The infection most often destroys the vertebral body, and collapse occurs. Nature tries to heal this process by fibrous and then osseous fusion. The usual antituberculous measures—good diet, improved hygiene, fresh air, sunshine, and immobilization of the spine—are in order. Recumbency in bed, plaster, or a curved frame secures this immobilization. A minimum period of two years is always necessary before the patient can be permitted up. The criteria for permitting ambulation are: (1) freedom from pain and local tenderness, (2) good general condition; (3) no increase in kyphosis; (4) normal temperature, (5) gain in weight, and (6) healing as shown roentgenographically.

Operative fusion of the spine is favored as the best means of controlling deformity and permitting quicker and more permanent healing. Following operation, the patient should be kept recumbent for six months.

An analysis of the results of 100 cases studied at the Crippled Children's Hospital in Iowa City is presented. These results briefly are as follows: 94 per cent. of the attempted fusions were successful, the Hibbs, Albee, and other modifications were equally successful. In 96 per cent. the deformity was decreased or its progress was stopped. Paralysis was relieved or its progress was arrested in 76 per cent. of the cases following fusion. In 89 per cent. of cases in which there was abscess formation or a sinus, healing occurred.

The age of the patient does not seem to influence the good results of fusion. Fusion does result in shortening the time of recumbency. It should be done only when the patient's general condition will permit it. If a patient is progressively getting worse, fusion is contra-indicated. When his general condition remains at a constant level or when he is improving is the best possible time for doing the fusion.—*Herbert E. Hipps, M.D., Marlin, Texas.*

SPINAL INJURIES WITH NERVE DAMAGE Ralph M. Stuck. *Southwestern Medicine*, XXIV, 157, May 1940

The vital importance of proper intelligent first aid on any spinal or cervical injury is emphasized. Hyperextension of the spine where there is an injury to the thoracic or



lumbar region, and gentle traction on a cervical spine injury is the proper way to handle and transport these patients.

An immediate estimate of the severity and location of the level of the spinal lesions is important and may be made on the following observations:

- (1) Ask patient to move hands and feet gently.
- (2) Observe skin area involved in sweating and "gooseflesh". This will usually correspond to the sensory level of the lesion.
- (3) Observe and record the sensory level, reflexes, motor power, and level of pain.
- (4) Pinch great toe. If there is no sensation the spinal cord is probably completely severed.
- (5) Note any angulation of spine.
- (6) Examine back of neck for any evidence of forward dislocation of first four cervical vertebrae.

After this preliminary estimate is made and the patient's shock has been overcome, a more complete neurological examination can be made.

If there is a continual increase in the degree of paralysis, laminectomy is indicated. It may also be done as late as a week or more after an injury, if there are evidences of compression.

The type of operation done is discussed and the importance of good postoperative care is emphasized.—*Herbert E. Hipps, M.D., Marlin, Texas.*

FOREIGN BODY ARTHRITIS. J. Albert Key. *Surgery, Gynecology and Obstetrics*, LXX, 897, May 1940.

The writer describes six cases of arthritis secondary to the presence of a foreign body in or in close proximity to the joint. Four of these patients were operated upon, and the pathological findings are described. Findings of degenerative arthritis were present in all with some variation in degree, possibly due to the duration or type of foreign body. Infective organisms were not found in these cases, although a low-grade chronic infection was suspected in two. The obvious conclusion is reached that foreign bodies in or near joints should be removed before the degenerative changes are produced. The article is well illustrated with roentgenograms; no microphotographs are shown.—*Richard McGovney, M.D., Santa Barbara, California.*

THE SURGICAL TREATMENT OF RECURRENT DISLOCATION OF THE SHOULDER JOINT. Svante Orell. *Surgery, Gynecology and Obstetrics*, LXX, 945, May 1940.

The writer gives a short résumé of surgical methods of preventing recurrent dislocation, which are based on correction through the bones of the joint; the method of Bankhart, however, is not included. The author presents one case corrected by his own method. This consists in making a fissure extracapsularly in the anterior rim of the glenoid with a special osteoperforator and inserting into it a pointed os purum transplant, which is allowed to project slightly. Postoperatively, the arm is dressed in adduction for two weeks, and then active motion is started. This method gave a stable joint with excellent motion in the case reported.—*Richard McGovney, M.D., Santa Barbara, California.*

VITALLIUM NAILS IN FRACTURES OF THE HIP. Charles S. Venable and Walter G. Stuck. *Surgery, Gynecology and Obstetrics*, LXX, 964, May 1940.

The writers show that any metal alloy which is electrolytic is subject to corrosion when placed in bone. Authors are quoted, and photographs of corroded hip nails are shown to develop the idea. Vitallium—which is an alloy of cobalt, 65 per cent.; chromium, 30 per cent.; and molybdenum, five per cent.—is non-electrolytic and completely passive in the tissues. Nails made of vitallium must be cast, but do not loosen in the bone or cause formation of sterile fluid about them. The writers note twenty intra-

capsular femoral-neck fractures fixed with vitallium nails; in nineteen of these firm bony union was obtained without late complications. The one failure was due to a technical fault.—*Richard McGovney, M.D., Santa Barbara, California.*

AN OPERATION FOR CHRONIC DISLOCATION OF THE INFERIOR RADIO-ULNAR ARTICULATION. Judson L. Taylor. *Texas State Journal of Medicine*, XXXV, 278, 1939.

This is an operation analogous in principle to that used by Nicola in treatment of recurrent dislocation of the shoulder by transplantation of the long head of the biceps through a hole drilled in the femoral head. The lateral half of the distal four inches of tendon of the extensor carpi ulnaris is used to pass through a hole drilled through the dorsum of the head of the ulna and is resutured to the other half of the tendon.

The author reports one case of chronic dislocation of the inferior radio-ulnar articulation treated by this operation with a successful result.—*J. Y. Sher, M.D., Iowa City, Iowa.*

BEITRAG ZUR HISTOGENESE DER OSTITIS DEFORMANS PAGET (Contribution to the Histogenesis of Paget's Disease). Heinz Koops. *Vinchows Archiv für pathologische Anatomie und Physiologie*, CCCIV, 397, 1939.

On the grounds of microscopic findings the author claims that Paget's disease does not start in the lamellae of the bone, but at the border of the marrow cavity. The first change is a process which consists of the increased density of the marrow tissue and loosening of the endosteum. The beginning of the resorption of the cancellous bone does not begin until after the above has taken place. The process is followed by the disappearance of the cells of the marrow tissue, caused by latent serous inflammation ending in the marrow tissue with the formation of fibrous marrow tissue, and the bony lamellae with the formation of so-called mosaic structure.—*T. J. Gieteman, M.D., Iowa City, Iowa*

BEOBACHTUNGEN UBER DIE BEZIEHUNGEN ZWISCHEN RACHITIS UND TETANIE (Observations on the Relationship between Rickets and Tetany). E. Hennig. *Zeitschrift für Kinderheilkunde*, LXL, 379, 1939.

One hundred and forty children suffering from rickets were observed in a hospital in Berlin from 1933 through 1937. Calcium and inorganic phosphorus values were determined in the blood serum on a fasting stomach.

The author found that only twenty-five, or 17.8 per cent., of the children had pure rachitic changes. One hundred and fifteen, or 82.1 per cent., of the children had symptoms of tetany together with the rachitic changes. Of the latter group, thirty-six, or 31.3 per cent., had latent tetanic signs and seventy-nine, or 68.7 per cent., had manifest tetanic signs.

In the cases having signs of tetany the blood-serum phosphorus was over four milligrams per 100 cubic centimeters in 40 per cent. and in the other 60 per cent. it was in the rachitic realm. Some of the children showed phosphorus values corresponding to those seen in pure rickets.

It is the opinion of the author that tetany is seen as a healing stage of rickets.—*A. E. Bheden, M.D., Iowa City, Iowa.*

# The Treatment of TUBERCULOSIS OF THE SPINE

## *A Symposium*

PRESENTED AT THE ANNUAL MEETING OF THE  
American Academy of  
Orthopaedic Surgeons  
BOSTON, MASSACHUSETTS

on January 23, 1940

- I. Introduction and Outline —  
A. Bruce Gill, M.D., *Chairman*
- II. Pathology —  
J. Albert Key, M.D.
- III. Pathogenesis and Medical Treatment —  
J. Burns Amberson, Jr., M.D.
- IV. End Results of Treatment —  
Walker E. Swift, M.D., Mather Cleveland,  
M.D., Henry W. Meyerding, M.D., Fremont  
A. Chandler, M.D., Z. B. Adams, M.D., Rob-  
ert I. Harris, M.D., Leo Mayer, M.D., Paul  
P. Swett, M.D.

*Because of the urgent request that the papers included in this Symposium be published as a group, they are presented herewith as a supplement to this issue of THE JOURNAL. A limited edition of this Symposium is also available in pamphlet form.*

# THE TREATMENT OF TUBERCULOSIS OF THE SPINE

## INTRODUCTION

BY A. BRUCE GILL, M.D., PHILADELPHIA, PENNSYLVANIA, *Chairman*

This symposium of papers on the treatment of tuberculosis of the spine has been arranged in the hope that certain differences of opinion among us as to methods of treatment may be thoroughly discussed and, as far as possible, may be settled. We have asked our speakers to present their observations and the end results with patients treated for a period of at least five years, although believing that we would obtain a much more accurate picture of this disease if we could know the results twenty-five years after the onset of symptoms.

I trust, moreover, that this discussion may serve a far greater and more important purpose than to reconcile what, after all, may be but minor differences among ourselves. We may be led to seek a better understanding of the nature and the course of this chronic disease, to observe and to comprehend its phases, variations, and relations to other conditions of the body. We may even come to question whether we, as orthopaedic surgeons, are doing all that might be done to aid nature in the cure of tuberculosis of the spine.

We say that tuberculosis of the spine is a local manifestation of a general chronic disease. We recognize that the infection is carried to the spine through the blood stream from some primary or secondary focus in another part of the body. We observe concomitant or subsequent lesions elsewhere. But do we comprehend fully the implications of this statement and understand the vital connection between the local and the general condition? We give much attention to the necrosis in the spine. Do we give too little attention to the chronic tuberculosis in the body?

It is true that the foci in soft tissues and in bone may become permanently healed, but it is also true that within twenty years from the onset of Pott's disease many patients die of causes directly attributable to tuberculosis. Some years ago in the study of a small group of cases I found a mortality of 35 per cent. during this period. The deaths had been due chiefly to pulmonary, miliary, and meningeal tuberculosis. Some patients, in the years subsequent to apparent healing of the spine, whether treated conservatively or by operation, developed spastic paralysis, renal complications or other bone and joint disease.

Is it not true that in treating tuberculosis, wherever found, we are dealing with a very chronic, insidious, and resistant disease, and that the ultimate victory or defeat depends greatly on the body's ability to combat and stay this infection?

So, today, we ask ourselves again, what are the objectives at which

we aim in our treatment of tuberculosis of the spine? Surely they include the following:

1. The relief of pain.
2. The healing of the spine.
3. The prevention or the cure of deformity so far as this may be compatible with healing.
4. The prevention and cure of complications.
5. The prevention of relapse or of recurrence of the disease in the spine or elsewhere.
6. The prolongation of life.

In connection with these objectives there are many questions which we may attempt to answer:

1. What is the mortality in Pott's disease, and to what causes is it due, either directly or indirectly related to the disease of the spine?

2. What are the evidences of healing of the spine? Is fusion of the vertebral bodies an accurate criterion of permanent cure; and, if this be true, is it the only one?

3. Is the prevention or the correction of deformity compatible with healing, and, therefore, desirable?

In answering this question we must clearly distinguish between two types or forms of vertebral necrosis. In the one form, known as the epiphyseal variety, the disease begins in the epiphysis beneath the intervertebral disc and extends into the body. If the adjacent vertebra is similarly affected, with disappearance of the disc, there may occur a bony fusion of the two vertebrae with but little destruction of the bodies. Healing may thus occur with minimal deformity. In the other form, or the central variety, there usually occurs a complete destruction of the body. If two or more contiguous vertebrae are so destroyed, how can there be fusion without marked deformity?

4. Practically all of us agree that adults should be operated upon unless there is some individual contra-indication. We are divided into two opposing camps as to the advisability of operating upon young children and particularly upon those who are in the acute or progressive stage of the disease. We are in accord that prolonged rest is indicated but in discord as to the methods by which rest or immobilization should be secured.

Are there pathological or anatomical and physiological characteristics of the two age periods that would indicate a different method of treatment for each?

Does operative bridging of the posterior segment of the spine in children by either the Hibbs or the Albee method hasten cure, prevent deformity or complications, and lengthen life? Does it result in cure more frequently than do conservative methods? We do not particularly wish to know in what percentage of cases a skillful operation will produce a permanent fusion of the processes of the vertebrae, but rather in what percentage it will produce a fusion of the bodies or otherwise result in a lasting

cure. Are the final results better at the end of ten or twenty years than they are in those cases which have been treated by equally skillful non-operative methods?

5. What are the complications of Pott's disease and how should they be treated? For example, should abscesses be aspirated? Is calcification of abscesses a sign of healing and is it desirable? Are these masses detrimental to healing if they are locked up in a bone cavity or if they lie between the vertebral bodies or in the soft tissues adjacent to or at some distance from the spine?

What is the incidence of spastic paralysis and at what time does it appear?

How frequently do sinuses appear? What effect do they have upon the prognosis for healing of the spine and for length of life?

6. Finally, should we regard these cases simply as an orthopaedic problem of localized tuberculosis of the spine to be cured in one year or in five years, or should we keep these patients under observation and guidance for many years as does the internist in treating pulmonary tuberculosis? Can we ever forget that the disease is a lurking danger unless the body maintains continually a high level of resistance? In the last analysis, is the local treatment, however valuable, of greater importance than the general treatment of the body as a whole?

# THE PATHOLOGY OF TUBERCULOSIS OF THE SPINE

BY J. ALBERT KEY, M.D., ST. LOUIS, MISSOURI

*From the Department of Surgery of the Washington University School  
of Medicine, St. Louis, Missouri*

In Pott's disease, as in other forms of skeletal tuberculosis, it is generally believed that the tubercle bacilli reach the bone through the blood stream, which they enter from foci elsewhere in the body—usually the peribronchial or retroperitoneal lymph glands. Fraser, however, emphasizes the peculiar tendency of the disease to localize in the bodies of the lower thoracic and upper lumbar vertebrae and he is not quite convinced by the usual explanation that this area is subjected to greater weight-bearing and greater strain and contains more cancellous tissue than do other areas of the spine. In seeking an explanation, he notes the close relationship of the thoracic duct to the bodies of the vertebrae in the areas where the disease tends to occur most frequently and suggests that the tubercle bacilli may reach the vertebrae from the overlying duct and its related lymphatics.

Fraser also notes that cancellous tissue containing normal red bone marrow is highly resistant to infection by the tubercle bacillus, but that cancellous tissue showing marrow degeneration is peculiarly liable to become infected. When a tuberculous infection is present in the lymph nodes overlying a vertebral body, the adjacent cancellous tissue shows degenerative changes which render this area especially vulnerable to the tubercle bacillus.

Either or both of the above explanations may be true, but either from the blood stream or from adjacent infected lymphatic tissue tubercle bacilli reach the area which is to become the site of the disease and settle there and multiply. Whether or not a minor injury which causes a slight extravasation of blood, but not a severe inflammatory reaction, is a factor favoring the localization and growth of the bacilli, is a question.

As the bacilli increase in number there is a reaction in the surrounding tissues. Observations on experimental animals indicate that the initial reaction to the tubercle bacilli is an acute inflammation with an accumulation of leukocytes in the area. An abscess is not produced, but the leukocytes soon disappear or are phagocytosed by macrophages, and monocytes and epithelioid cells appear in the area. These cells can be identified by the presence of a rosette of fine granules, which stains salmon pink with neutral red in supravital preparations. It is believed that the epithelioid cells are developed from the monocytes and that the monocytes are developed from the primitive connective-tissue cells. Sabin, Doan, and Forkner have studied the reactions of the connective tissues to various fractions of the tubercle bacillus and have shown that the lipid fractions of tubercle bacilli, especially the phosphatide A<sub>3</sub>, contain factors

which stimulate the multiplication and maturation of monocytes and epithelioid cells and epithelioid giant cells.

As the monocytes and epithelioid cells increase in number they tend to form a minute, roughly spherical mass or tubercle. The tubercle contains no blood vessels and its cells are supported by a delicate reticular structure. Sabin, Doan, and Forkner have shown that the stimulus to the formation of tubercles resides in certain fatty acids of high molecular weight which are found in tubercle bacilli. As the tubercle increases in size its central portion undergoes caseation. This is a form of degenerative change in which the cells die, losing their staining characteristics and disintegrating without liquefaction to form a finely granular residue. In this caseous central area there may be a variable number of fat droplets and fragments of cells in various stages of degeneration. Its peripheral zone is composed of dead or dying epithelioid cells.

In addition to the epithelioid cells the tubercle usually contains one or more giant cells of the epithelioid or Langhans type. These tend to be smaller than the foreign-body giant cells; they are characterized by a finely granular central area of protoplasm and exhibit a tendency for the nuclei to be arranged around the periphery of the cell. When stained supravitaly with neutral red, the finely granular central area of the epithelioid giant cell stains a salmon pink and resembles the rosette of the monocytes and epithelioid cells. The epithelioid giant cell may attain a considerable size and contain twenty or more nuclei, but as a rule it is relatively small and contains only six or eight nuclei. The foreign-body giant cells which appear later in the disease may be much larger and may contain 200 or more nuclei, which are scattered irregularly throughout the cell. Doan, Sabin, and Forkner have shown that the epithelioid giant cell is derived from a single monocyte or epithelioid cell by amitotic nuclear division, while the foreign-body giant cell is formed by the fusion of many cells, which may be of different types.

If the tubercle is sectioned and stained for acid-fast organisms, a few tubercle bacilli may be found in the sections. These may be in the caseous material or extracellular in the mass of epithelioid cells, but they are usually in these cells or in the giant cells. In my experience, however, it is difficult to find the organisms in sections from tuberculous bone in human beings.

The necrosis of the central portion of the tubercle appears to be due to a lack of blood supply rather than to any toxic effect of the tubercle bacillus on the epithelioid cells or giant cells. This belief is based on observations on experimental tuberculous arthritis in the knee joints of rabbits. In this material many apparently living and healthy epithelioid cells and epithelioid giant cells contain considerable numbers of apparently normal tubercle bacilli. One gains the impression that these bacilli not only live, but thrive and multiply in the protoplasm of these cells and that this may occur without causing visible damage to the cell. In other words, the epithelioid cell, instead of serving as part of the defense



mechanism of the body, appears to serve as a host for the tubercle bacillus and aids in the spread of the disease to the adjacent tissues.

Around the periphery of the mass of epithelioid cells is a zone of small round cells or lymphoid cells, and outside of this there develops a zone of non-tuberculous inflammation in which the smaller blood vessels are increased in size and number and in which there is a mild proliferation of the fixed connective-tissue cells, small round cells, and macrophages. This tissue is oedematous and possesses a delicate connective-tissue framework.

In instances in which the resistance of the individual is sufficient to cope with the infection, the fibroblasts in this non-tuberculous inflammatory zone proliferate and form mature collagenic fibrous tissue, which surrounds the minute tubercle. As this fibrous capsule matures and contracts, it isolates the epithelioid-cell mass with its tubercle bacilli from the rest of the body and they may ultimately die.

In the individual in whom Pott's disease is to develop, no adequate capsule is formed, but the epithelioid cells and tubercle bacilli invade the non-tuberculous inflammatory tissue and either form more tubercles or produce tuberculous inflammatory tissue, which contains large numbers of epithelioid cells. This highly cellular tuberculous inflammatory tissue invades the surrounding tissue, much as does a neoplasm, and bone, cartilage, and even dense fibrous tissue offer only a temporary barrier to its progress. Its periphery is highly vascular, but its central portion is so crowded with cells that blood vessels are obliterated and consequently this area degenerates and a tuberculous abscess is formed. This granulation tissue may contain a variable number of tubercles and these may enlarge and coalesce to form an abscess.

The abscess cavity contains cell debris and caseous material, but its contents are more liquid than is the caseous material of the tubercle and are purulent in character. During the active stage of the disease the wall of the abscess, which is composed of tuberculous granulation tissue backed by fibrous connective tissue, secretes, or at least permits the passage of fluid into the cavity, and the abscess increases in size and burrows through the surrounding tissues, following the path of least resistance, but maintaining a definite limiting wall until it ruptures through the skin, when its contents are expelled and its walls collapse, although the channel of tuberculous tissue may persist as a sinus as long as the disease is active. In other instances the disease may quiet down and the abscess may decrease in size as its contents become inspissated, and calcium may be deposited in its thickened avascular wall.

In cancellous bone the area of tuberculous granulation tissue is able to enlarge with relative ease, the hematopoietic red bone marrow tending to retreat before the zone of non-tuberculous inflammatory tissue and leaving an oedematous, sparsely cellular, fatty marrow which offers little resistance to the advancing disease. It is believed that this disappearance of the red bone marrow from the vicinity of an active tuberculous

focus is due to some toxins elaborated by the bacilli and diffused into the surrounding tissues.

The living bone trabeculae become atrophied in the hyperaemic zone of non-tuberculous inflammatory tissue and are more or less completely absorbed when they become engulfed by the zone of tuberculous inflammatory tissue. This absorption is partly due to osteoclasts, but it appears to be largely the work of the epithelioid cells. Just how these cells are able to bring about the absorption of living bone, we do not know. Not only does this tissue bring about the disappearance of the delicate trabeculae of cancellous bone, but it penetrates the relatively dense cortical bone and appears beneath the periosteum or ligaments, which it tends to strip from the bone as it spreads over its surface. Likewise, this tissue, in which the epithelioid cells predominate, is able to erode and to penetrate articular or epiphyseal cartilage without great difficulty. It does have difficulty when it encounters dense fibrous tissue, but even this gives way eventually when subjected to the constant pressure of the mass of growing tuberculous tissue.

It is characteristic of advancing tuberculosis that the bone plays a purely passive rôle and that little or no new bone is formed to buttress or to replace that which is being destroyed. Nor is there any stimulus to the formation of new bone, such as is present when bone is invaded by a pyogenic organism. Furthermore, in tuberculosis it is living bone which is destroyed, and the disease does not appear to cause necrosis of bone except by mechanically shutting off its blood supply. In fulminating disease the advancing zone of tuberculous inflammatory tissue may engulf trabeculae and pass on before they are completely absorbed, leaving the trabeculae projecting into the degenerating and caseous deeper layers of the diseased tissue. Such trabeculae die and are broken off and persist in the pus of the abscess as bone sand, as this pus has little power to dissolve dead bone.

Rarely, sequestra of considerable size are formed and these are frequently triangular or wedge-shaped. Consequently, it is generally believed that they are due to emboli or to sclerotic occlusion of the nutrient artery which supplies this particular portion of the bone. Emboli have not been demonstrated, and sclerosis is a phenomenon which occurs in the healing of a tuberculous lesion. Consequently, I believe that the rare large sequestra are produced by the given area being surrounded by the tuberculous tissue which cuts through the bone on all sides of it and thus deprives it of its blood supply. This area thus becomes necrotic before it is invaded and destroyed and may persist indefinitely, as the tuberculous tissue has little power to destroy dead bone.

In tuberculosis of the spine it is usual to classify the cases as of the central, epiphyseal, and anterior types. Very rarely the disease begins in the posterior arch or transverse process, but this type is not really Pott's disease and will not be considered in this paper. In a series of 109 lesions studied by Doub and Badgley the disease was of the central type

in sixty-one, epiphyseal in forty, and anterior in eight. These lesions occurred in 100 patients, the incidence of multiple foci being about 10 per cent. This classification was based on x-ray studies of the spines and while the roentgenograms do not show the very early lesions, they do show the areas of greatest destruction, and it may be assumed that the disease began in these areas.

It is usually stated that the localization of the disease in the central, anterior, and epiphyseal regions of the bodies of the vertebrae is determined by the arrangement of the blood vessels, which are divided into central, anterior, and epiphyseal groups, and of course this is in a measure true. However, it is to be noted that infection in the epiphyseal region which has a relatively poor blood supply is frequent when compared to that in the anterior portion of the body, which not only has a rich blood supply, but is adjacent to the diseased lymphatic tissue, which, according to Fraser, is the source of the disease. It is further to be noted that the anatomical arrangement of the blood vessels in the various bones is used to explain the localization of hematogenous osteomyelitis and of tuberculosis. Yet pyogenic bacteria rarely cause disease of the spine and frequently cause disease of the long bones, while about half of all skeletal tuberculosis occurs in the spine. It is thus evident that the arrangement of the blood vessels is not a satisfactory explanation and that we do not yet know why the spine is peculiarly susceptible to tuberculosis.

In the central type of disease the infection begins in the interior of the body of the vertebra and spreads through and destroys the cancellous tissue until it reaches the cortex, usually in the anterior portion of the body. The cortex is then penetrated and tuberculous tissue accumulates beneath the anterior longitudinal ligament, which is stripped up from its attachments to the bone and to the adjacent intervertebral discs. The disease may thus reach and invade the bodies of the vertebrae above and below without passing through the intervertebral discs. Likewise, it may erode the posterior cortex to appear beneath the posterior longitudinal ligament, and the tuberculous tissue may penetrate this ligament and spread over or completely encircle the dura at the level of the disease.

The central type of disease may cause no symptoms until a considerable portion of the body of the vertebra is destroyed and the bone collapses or until the cortex of the vertebra is perforated and the disease appears beneath the ligaments, which serve as periosteum, and causes localized pain. It is thus evident that this type of disease is not often diagnosed until considerable destruction is present.

The anterior or superficial type of spinal tuberculosis begins in or near the anterior cortex of the body and spreads up and down the spine beneath the anterior spinal ligament to invade and to erode the anterior portions of the bodies of the adjacent vertebrae, without causing much damage to the intervertebral discs or collapse of any vertebral body until late in the disease.

The epiphyseal or intervertebral articular type of disease begins in or near the upper or lower surface of the body and spreads to the intervertebral disc and through the nucleus pulposus to the adjacent vertebra. This type of disease causes symptoms relatively early and can be diagnosed in the roentgenogram by the narrowing of the intervertebral space. It was present in 37 per cent. of the lesions studied by Doub and Badgley. I know of no pathological observations on early cases of the epiphyseal or intervertebral type of disease, but Knaggs shows an excellent example, which is fairly early and exhibits complete destruction of the nucleus pulposus and very little destruction of the adjacent vertebral bodies. Apparently this type does not occur in young children where the cartilage adjacent to the intervertebral disc is quite thick and offers a much firmer barrier to the spread of the disease than does the delicate cancellous bone of the vertebral body. Doub and Badgley note that the epiphyseal type of disease rarely causes collapse of the vertebral body and that it may heal without appreciable deformity.

From pathological studies on seven spines of children who had Pott's disease, Compere and Garrison concluded that the intervertebral disc was highly resistant to destruction by tuberculous granulation tissue. This is, of course, true in children, but the observations of Doub and Badgley indicate that it is not true in adults.

As has been stated, when the tuberculous focus reaches a certain size its central portion becomes necrotic and may caseate, but, if the disease is advancing, it tends to liquefy and form an abscess, which increases in size as long as the disease is progressing. The abscess appears beneath the anterior longitudinal ligament and first elevates, then penetrates this ligament, and forms a cavity lateral or anterior to the spine. As the abscess enlarges it follows the path of least resistance through the surrounding tissues and may generate considerable internal pressure before it finds its way to a soft, yielding area where the pressure is dissipated. Two or more abscess cavities may arise from a single focus in the spine. Abscesses which arise above the diaphragm tend to remain in the chest cavity or to point posteriorly. Those which arise below the diaphragm tend to enter the pelvis along the sheath of the iliopsoas muscle and may point in the groin or thigh, or they may burrow posteriorly and appear in the lumbar region.

After the abscess ruptures and discharges its contents or is drained, the tuberculous sinus which persists is vulnerable to infection by pyogenic organisms, and this is a complication which is usually dreaded. Personally, I do not think that the secondary infection is so very important. If the patient has little or no resistance to the tuberculous disease and is going down hill steadily, the secondary infection may add the *coup de grâce* to a hopeless situation, but secondary infection in abscess cavities which are well walled off and amply drained is rarely dangerous and usually clears up when and if the tuberculous focus heals.

A distressing complication which occurs in about 12 per cent. of

the patients with Pott's disease is paraplegia. Weeden Butler and Seddon, in two excellent papers, submit their observations on 186 patients with Pott's paraplegia. They emphasize the fact that the only constant etiological factor found in the usual type of paraplegia which occurs in early active Pott's disease and diminishes in direct relationship to the subsidence of the infection, is the presence of active tuberculosis in immediate relationship to the dura mater. As has been stated, the tuberculous granulation tissue may completely surround the spinal cord, being separated from it by the dura. This membrane affords a very firm barrier to the tuberculous tissue and is not invaded by the disease. Consequently, a pachymeningitis does not occur. However, Weeden Butler points out that even without mechanical compression of the cord the presence of active tuberculous granulation tissue in intimate contact with the dura may cause degenerative changes in the cord, which appear to be the result of the general toxic and vascular reaction occurring in the vicinity of any active tuberculous focus, and if this condition persists long enough the paralysis will be permanent. However, it is to be noted that even in this type of paralysis with no obvious compression of the cord, mechanical pressure is a factor in the paralysis, because this tends to clear up when an abscess communicating with the focus in the bone and thus with the epidural granulation tissue is drained, either by spontaneous rupture or by costotransversectomy.

Due to the position of the articular facets, destruction of the bodies of the vertebrae in the thoracic region results in more extensive collapse and more acute angulation than does an equal amount of destruction in the cervical or lumbar region. But even in the thoracic region, with destruction of the bodies of several vertebrae and marked angulation, the spinal canal is not narrowed sufficiently to embarrass the spinal cord seriously. However, if the pedicles and articular facets are destroyed a pathological dislocation may occur and the cord may be pinched by the persisting posterior margin of the vertebra above or below, and permanent total paralysis may occur. A similar result may follow the rare concertina-like collapse of a vertebral body whose pedicles and articular facets have been destroyed.

Very rarely, a large, loose sequestrum or mass of caseous material may be forced back into the vertebral canal and may compress the cord.

We know that tuberculosis of the spine is in many respects a self-limited disease; that it tends to progress for a period of months or years and that then, either with or without treatment, an equilibrium is established between the resistance of the patient and the virulence of the organisms; that the patient may remain *in statu quo* for awhile; and that finally the defensive mechanisms of the body get the upper hand and the lesions in the spine tend to heal by fibrosis. In children the remains of vertebral bodies which are in contact tend to fuse by bone, and compensatory curves develop above and below the lesion. In adults the fusion is usually by dense fibrous tissue.

It is probable that no tuberculous spine ever heals completely and that there always persist foci of disease, which may become active if conditions arise that sufficiently favor the disease. I believe that spinal fusion tends to lessen the probability that such conditions will arise and that it tends to hasten the healing process if it is done without lowering the patient's resistance too much.

We need more studies on the process of healing in Pott's disease, as most of the pathological work has, of necessity, been done on patients in whom healing did not occur. While the roentgenogram shows only the more gross lesions, it may yet throw considerable light on this phase of the disease.

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# PATHOGENESIS AND MEDICAL TREATMENT OF TUBERCULOSIS OF THE VERTEBRAE

BY J. BURNS AMBERSON, JR., M.D., NEW YORK, N. Y.

In the United States, since bovine tuberculosis has been reduced to the point where only 0.4 per cent. of the cattle are infected (Mohler), the disease in man is due almost exclusively to infection with the human type of bacillus. With very few exceptions, infection is acquired by inhalation, and the primary lesions are pulmonary. The early passage of the organisms from the pulmonary focus to the bronchopulmonary lymph nodes sets up lesions there which, in children, are usually much more extensive than those in the parenchyma. This caseating lymphadenitis is the source from which most hematogenous infections originate, the bacilli gaining access to the blood stream at the junction of the lymphatic trunks and the innominate veins.

There are several very conspicuous factors which influence the liability to hematogenous dissemination. The more extensive and progressive the caseous lymphadenitis, the greater is this tendency. In turn, the severity of the lymphadenitis is dependent greatly on the intensity and frequency of repetition of the early infections and on the age and race of the patient. Extensive lymphadenitis and severe and fatal forms of hematogenous dissemination occur chiefly in infancy and in early childhood; both are more conspicuous in negroes, even in adults. Two-thirds or more of the deaths from tuberculosis occurring in children under the age of five can be traced to these forms,—chiefly tuberculosis of the meninges and the central nervous system. By contrast, over 95 per cent. of such deaths among people past fifteen years of age are due to chronic pulmonary disease. The trends, therefore, are very pronounced: the younger the child, the larger the lesions of caseous lymphadenitis and the greater the liability to hematogenous dissemination. The older the person, particularly beyond the age of puberty, the greater is the tendency to localization in the lungs, the less to hematogenous spread. There are exceptions, as in old men, but these are not sufficiently significant to nullify the rule.

Lesions developing from invasion of the blood stream appear predominantly in the lymphatic system, the meninges and the central nervous system, the serous membranes, the skeletal system, and the genito-urinary system. Factors which favor these localizations include the arrangement of blood vessels and the distribution of the monocytic cells of the reticulo-endothelial system by which tubercle bacilli are engulfed and in which they survive for considerable time.

After localization of the infection in various structures, if the victim survives, further progress of the disease is likely to be confined to single systems such as the respiratory or the genito-urinary. Local developments depend on such factors as compactness of the organ and spatial

relationships. Thus, the lungs are particularly vulnerable, because they may be infected not only by inhalation but also by hemic transport of the bacilli, regardless of the point of their entry into the venous circulation. Furthermore, since the lungs are richly vascular, mobile, tubular, and areolar structures, the opportunity is great for the diffusion of toxins and the local dissemination of the infection.

A feature of tuberculosis is its frequent latency and subsequent reactivation. If lesions are not sufficiently severe or disseminated to cause a child's death within a few months or years after infection, they settle often as latent caseous residua and usually become more or less encapsulated. The latent state may continue during later childhood until adolescence, when one or more of the foci may become reactivated, most often in the lungs. This feature seems responsible for the rapid accretion of progressive pulmonary lesions between the ages of eighteen and thirty-five. The mechanism of reactivation is not understood clearly, but depends apparently on fundamental constitutional alterations that fertilize the soil in which tubercle bacilli are much more likely to thrive.

#### PRINCIPLES OF PATHOGENESIS IN TUBERCULOSIS OF THE VERTEBRAE

Tuberculosis of the vertebral column accounted for 698 deaths in the registration area of the United States in 1937,—431 in men, and 267 in women. This represents approximately 1 per cent. of the deaths from all forms of the disease, and approximately 12 per cent. of those from extrapulmonary tuberculosis. In Switzerland, Kaufmann estimated that from 1931 to 1935, 8.5 per cent. of all fatal extrapulmonary organ tuberculosis was caused by disease of the vertebral column.

It is interesting to know how closely vertebral tuberculosis follows some of the general laws of pathogenesis. Because of the difficulty of detecting early lesions, the time of the first involvement of the vertebrae has not been as clearly recognized as in the case of the lungs. However, on the basis of a study of 1259 cases, Whitman reported in 1927 that in 85.8 per cent. of the cases the disease develops before the age of ten, the apparent onset occurring most commonly between the third and the tenth years. Recently Hellstadius, by more exact methods, has found two peaks of incidence of "primary" spondylitis\*: the first between birth and nine years of age and the second, somewhat higher, between the ages of twenty and thirty-five; after this age the incidence of the "primary" type declines rapidly. The first peak coincides with that of the other early hematogenous disseminations mentioned and is easily understood. The second is more difficult to explain. Wallgren and Lundblom believe that this postpuberty peak is related to a sharp increase in the incidence of primary exogenous infections acquired by young people as they extend their activities farther from the home and more deeply into a contaminated environment, but there is reason to

\* He distinguishes the first vertebral focus as "primary" and direct extensions to adjacent vertebrae as "secondary".



doubt the correctness of this assumption. Considering parallel phenomena already mentioned, the incidence of progressive pulmonary disease in this age period is too great to be explained by the effect of extrinsic factors alone and appears to be related in considerable part to constitutional variations. In vertebral as well as in pulmonary tuberculosis, the peak of incidence of progressive disease after puberty exceeds the slope of the curve of incidence of infection. In other words, incidence of infection determined recently in large groups of the American population (Douglas and Harmon) rises gradually and not as a peak at this time of life.

There is other evidence to indicate that lesions which are established in the vertebral bodies early in life, if they do not soon become progressive and destructive, may subside into latency to remain permanently in this state or to be reactivated later by influences similar to those which affect pulmonary foci. Randerath found the bone marrow invaded almost invariably in acute generalized miliary tuberculosis and in eighteen of a series of twenty-two cases of chronic extra-osseous tuberculosis,—mostly pulmonary. Koizumi demonstrated tubercle bacilli in the bone marrow in 75 per cent. of a series of cases of chronic organ tuberculosis. Since obviously few of these lesions ever become progressive, the necessary assumption is that, if the patient survives, most of them become healed or latent, and that constitutional or local influences later may be responsible for the exacerbation of some of them. Trauma, for example, may cause reactivation of such a latent focus. Few believe now that the effect of trauma is to establish a locus of lowered resistance in which circulating tubercle bacilli are likely to lodge.

Vertebral disease also follows some of the general laws which determine localization and subsequent evolution. The point of localization in the vertebral body is thought by some investigators (Hellstadius, Randerath, Konschegg, Janas) to be determined largely by the vascularity of the parts, the density of the tissues, the areas of growth, and the richness of red bone marrow. Randerath, for instance, observed more lesions in the red marrow than in the fat marrow and invoked this factor to explain the relative frequency of tuberculosis of the shafts of long bones in children and its relative rarity in adults. The actively growing anterior subperiosteal part of the vertebral body, rich in vessels, is given by a number as a cause of the evolution of lesions here. The relative softness of the growing osseous tissue, the more frequent and severe hematogenous infections in early childhood, and the lower general resistance which prevails then help to explain the more diffuse, destructive lesions of the vertebral bodies, the more frequent development of paravertebral abscesses, and the higher incidence of spastic paraplegia in the first ten years of life. In adults, by contrast, increasing specific immunity and the greater compactness of the bone structure help to account for the higher incidence of localized, less destructive lesions. Furthermore, hematogenous infections in adults are usually less severe than those in early childhood. Among several hundred nurses observed before and after becoming tuber-

culin positive for the first time, I have found only one case of early localized vertebral tuberculosis; no deaths have occurred in this group. Caseous lymphadenitis in the bronchopulmonary and mediastinal chain is much less frequent than in young children. There seems to be an increasing native resistance against the infection as the person grows older.

Developmental changes seem also to have an influence on the type and rate of healing of vertebral tuberculosis. In children, new-bone formation in a diseased vertebral body is reported to be more frequent than in adults. In adults, block formation is common; in children, relatively rare. Randerath has the conception that new-bone formation in children may be explained by the fact that the physiological growth center may be included in the domain of the lesion and may be stimulated by the diffused toxins. Finder's explanation of the healing process seems to harmonize with this view. In adults, calcification of pulmonary lesions is seldom observed before they have remained arrested for four or five years, and then only slowly. In children, calcification is usually more rapid and may be easily identified in the roentgenogram within a year. The fundamental reason for this difference, which may play a part in the healing of vertebral tuberculosis also, is not clear. Pagel has suggested that endocrine activity may be a factor, recalling that childhood is the period of greatest parathyroid function.

The law of Marfan, that tuberculosis of the bones excludes the likelihood of serious tuberculosis in other organs, has numerous exceptions. Bernard and his associates suggest that the law applies only to extrapulmonary lesions which have healed before puberty without extension to other organs. Sipos, Petter, Marienfeld, and others make it clear that many patients with vertebral disease have more or less serious tuberculous lesions elsewhere,—most often in the lungs. Von Hecker finds that associated pulmonary lesions are fewer in older patients, decreasing in his series from 63.6 per cent. in the age period of from one to three, to 5 per cent. in the age period of from twenty-two to twenty-four. Cave reports that 60 per cent. of 122 children with vertebral tuberculosis showed pulmonary lesions at some time during the course of the disease, as demonstrated by roentgenograms taken routinely every three months. Hematogenous disseminations are bound to strike many visceral organs. That many of the resulting lesions remain innocuous is proved by the finding of healed miliary tubercles in the liver, the spleen, and the kidneys in 20.1 per cent. of 452 consecutive cases examined routinely at autopsy in the Cleveland City Hospital by Reichle and Work. While most of these lesions remain latent, some assuredly will progress. Meningitis predominates in infancy and in early childhood, but other forms, such as urogenital tuberculosis, are fairly common at later ages. Kaufmann found that 13.7 per cent. of the extrapulmonary lesions in his series were in the genito-urinary tract; he and others have pointed out the greater frequency in men after the age of twenty. From these reports and my own experiences, it may be said that thoracic lesions, apart from being the common

origin of vertebral tuberculosis, often complicate the picture because of their extent, activity, and chronicity, and that other associated hematogenous lesions are by no means rare. Wherever these may be situated, they occasionally progress simultaneously with the vertebral lesions or at some other time.

#### LIABILITY OF THE NEGRO

In 1935, the negroes of the United States comprised 9.5 per cent. of the total population. Thirteen per cent. of all deaths from all causes occurred in negroes. Twenty-seven per cent. of all deaths from tuberculosis were among negroes in 1935, as compared with 11 per cent. in 1910. In 1937, in the registration area of the United States, 27.5 per cent. of the deaths from all forms of tuberculosis occurred among the colored, and this group contributed 39.4 per cent. of the deaths from disseminated tuberculosis and 21.4 per cent. of those from tuberculosis of the vertebral column. Pinner and Kasper, in a comparative autopsy study, noted a decidedly greater relative incidence of hematogenous lesions in negroes and found evidence that this is a genetic characteristic. My own observations are in agreement and indicate that the negro shows a greater tendency to caseous tuberculosis and less effective healing powers, and, in the presence of vertebral or other hematogenous tuberculosis, a decided tendency to further dissemination of the infection.

#### CLINICAL APPLICATIONS

From these observations certain practical principles suggest themselves.

If exposure to infection is inevitable, the prevention of vertebral tuberculosis depends largely on the postponement of infection at least until after the years of early childhood and on the safeguarding of general health and resistance during adolescence when latent lesions sometimes become reactivated.

In any case of vertebral tuberculosis the source should be sought in the chest. The pulmonary focus may be insignificant, and the more important lesions are likely to be found in the lymph nodes of the mediastinum. Since the lesions at the source may fluctuate greatly at the beginning and even later, especially during adolescence, periodic roentgenographic observation should be made; during the period of instability this should be at intervals of three months or less.

Since the vertebral focus frequently is only one of a number of hematogenous lesions, others should be looked for at once and at intervals thereafter. The common points of localization should be investigated especially. Suggestive findings, such as traces of albumin and pus in the urine, necessitate further thorough examination.

If associated lesions are discovered, they should be studied and evaluated carefully, since these may be mild and latent or active and ulcerating and should be treated accordingly.

## PRINCIPLES OF MEDICAL TREATMENT

Tuberculosis of the vertebrae is invariably only one part of a systemic disease. This fact has many implications in treatment which should be designed to control other active lesions as well and to avoid the exacerbation of foci which at the time may be latent. It is a fundamental principle of treatment of any form of tuberculosis that adequate healing cannot be expected until activity has subsided and the processes of caseation and liquefactive necrosis have been arrested; then, and not before, healing may progress efficiently and steadily.

Since stabilization of the lesion is the first goal, rest treatment initially is intended for this purpose. Symptoms of toxæmia are watched, and it is invaluable to make periodic observations of the erythrocyte sedimentation rate and of the blood leukocytes. Quiescence is indicated by a trend to normal, while the lesion may show a subsidence of the destructive process simultaneously. This period of stabilization, indicating that the diffusion of toxins is becoming less and less, requires a variable time,—often many months. Afterwards, if reactivation is prevented, local healing progresses slowly.

There is no substitute for the general scheme of rest treatment in any form of tuberculosis, and it is particularly important in the case of recently developed disease. Proof of the value of rest treatment is empirical. It should not be supposed that this consists solely of rest of the local lesion. Healing depends not only on this but also on the preservation and enhancement of the general specific and non-specific factors which enter into resistance. Their vital importance is best demonstrated when they are impaired, as by malnutrition, fatigue, worry, menstruation, pregnancy, associated diabetes, and many other causes. Rest treatment, therefore, should include, if possible, the elimination or minimization of such deleterious influences in order to ensure the maintenance of vital resistance at a maximum level.

Speaking specifically, diet is now considered to be important in tuberculosis only in so far as it provides all the necessary elements in suitable amount and quality, well prepared and tastefully served. Beyond this, there is no proved efficacy in excessive dietary specialization. Physical agencies, such as heliotherapy, balneotherapy, and climatic treatment, are useful for their effect in preserving and stimulating physiological tone and in promoting mental and physical relaxation. Except for certain superficial tuberculous lesions, it is doubtful whether natural or artificial heliotherapy is lethal for bacilli in the tissues or that it accelerates healing in a specific way. Psychotherapy is important to help the patient resolve his personal problems, which otherwise may act to retard his progress. Serenity and calmness are powerful factors in promoting recovery.

There is no substitute for time in the healing of this disease, and even several years is not too long a period when one considers the alternative of repeated relapses, chronic invalidism, and early death.

In principle, operative interference in any form of tuberculosis is

most effective ultimately if time is allowed first for the active process to subside and fibrous encapsulation to begin. Then surgical treatment, while it does not necessarily accelerate healing, may create conditions in which healing will be most effective and durable. Certainly surgical treatment does not seem logical in the presence of actively disseminating tuberculosis when new lesions may appear at any time in some other organ in a serious and threatening form. The peculiar constitutional disposition of the negro in this respect should be seriously considered.

#### SUMMARY

Tuberculosis of the vertebrae conforms fairly closely in its time and mode of origin to the principles applying to other hematogenous disseminations. The disease usually starts in early childhood or during adolescence and early adult life; in the latter period some of the newly developing lesions probably result from the exacerbation of latent foci established many months or years previously.

The localization, evolution, and healing of vertebral lesions, likewise, are governed by principles which apply to other structures. The compactness, growth, vascularity, and other components of the bone, as well as the differences in native and acquired resistance, help explain the differences of behavior at various ages.

In negroes, vertebral tuberculosis is a more frequent, serious, and fatal disease than in whites.

In the presence of vertebral tuberculosis, a source in the chest should always be assumed and sought for, as well as hematogenous lesions in other systems such as the serous membranes, the lymphatics, and the genito-urinary tract. It is important to recognize these at any time, but especially during the early stages of vertebral disease. Periodic roentgenographic examinations of the chest should be made at frequent intervals, and the urine should be examined regularly for traces of albumin or pus. Suggestive evidence should always lead to further investigation. Too much reliance should not be placed on the observation that vertebral tuberculosis sometimes runs its course as an isolated lesion.

Treatment is aimed first at arresting hematogenous dissemination, diffusion of toxins from the vertebral lesions, and the destructive processes of caseation and liquefaction. Later, adequate time should be allowed for complete healing, which may require several years. Healing sets its own pace, and this cannot be accelerated materially except by rest treatment in its comprehensive meaning. Other measures may aid in securing a better, if not a quicker, result.

Attention is called to the principle that in any form of tuberculosis surgical treatment usually is most effective ultimately if it is postponed until the forces of resistance have become organized and the lesion has been stabilized and has started to heal. Surgical treatment may be futile and harmful if started prematurely, especially if the disease is still in the phase of hematogenous dissemination.

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# END RESULTS OF THE SPINE-FUSION OPERATION FOR TUBERCULOSIS OF THE SPINE

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For exactly twenty-nine years the Hibbs spine-fusion operation has been the treatment of choice for persons with tuberculosis of the spine who have come to the New York Orthopaedic Hospital. It was performed for the first time on January 9, 1911, and between that date and January 1, 1940, 1020 such patients have been so treated. They represent a motley group of all ages, of all stages of activity of the disease, and of all the variations in those factors which make up what is known as the patient's constitutional capacity to resist tuberculosis. The operation was thought of by Hibbs primarily in terms of the treatment of young children, and, although it has come to be used more and more for adults, no opportunity can be missed of reiterating and stressing the fact that spine fusion has its most beneficial results in young children.

In order that data on the really late results could be summarized, only those patients who were operated upon in the twenty-year period 1911 to 1930 inclusive have been considered. This allows the possibility that each patient could have a minimum ten-year period of observation. No patient has been included who was lost before he had had an examination by a surgeon at the Hospital five years after the operation. This, of course, eliminates a considerable number, but, as a matter of fact, the follow-up efficiency over this twenty-year period has been extremely good. Of the total of 817 patients, 71 per cent. are included in this study; of that 71 per cent., 61 per cent. have been observed regularly for periods of at least ten and up to twenty-four years after the operation. It is evident, therefore, that any conclusions drawn from this study are based on a large number and a great variety of patients, observed over a long period of time.

As observations have accumulated, a number of effects of the spine fusion on tuberculosis of the spine have become clear and demonstrable. Therefore, before presenting any statistics, it would seem a valuable part of this end-result study to state just what is and what is not expected of the operation.

A group of factors are present in each patient which cannot be completely evaluated in the beginning, but which exert a great influence on the course of the disease. For instance, one cannot tell just what degree of inherent capacity for resistance to the disease is present. It is hard to say just how virulent the particular infecting organisms are. It is difficult to detect by present diagnostic methods all of the parts of the vertebrae which are involved, or to know the exact amount of cancellous bone which has been or is about to be absorbed. One cannot foretell how well or how quickly any one individual's tissues will respond and set in

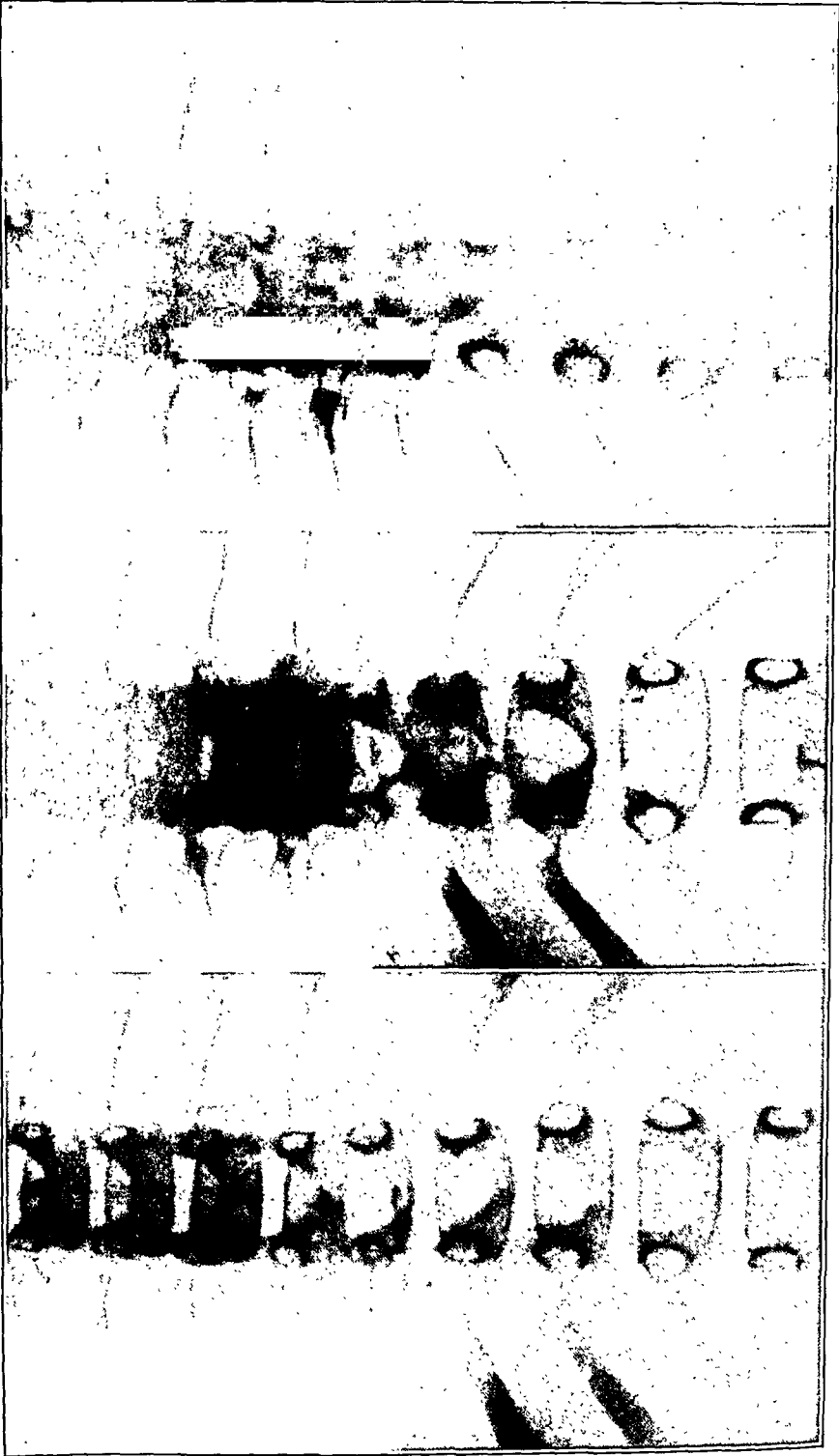


Fig. 1-C

Fig. 1-B

Fig. 1-A

Illustrating early disappearance of paravertebral abscess. The patient had a history of symptoms of four months' duration when fusion was done in 1929 at the age of four years. The lesion involved the eighth and ninth thoracic vertebrae, and the sixth to the eleventh thoracic vertebrae, inclusive, were fused. The patient was ambulatory after four months. The condition ten years after fusion was excellent.

Fig. 1-A: Preoperative film, showing paravertebral abscess.  
Fig. 1-B: Four months after fusion, showing no abscess.  
Fig. 1-C: Ten months after fusion, showing solid fusion and abscess entirely absorbed.



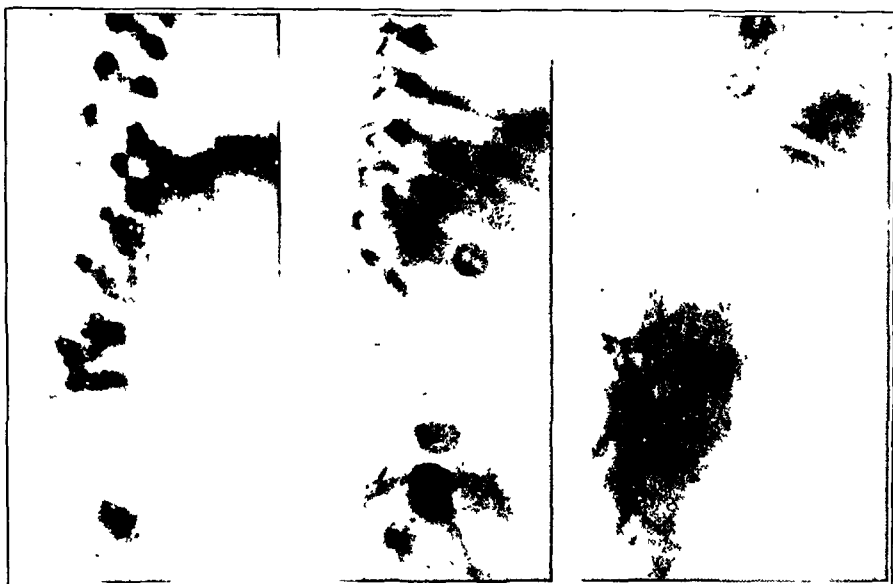


FIG. 2-A

FIG. 2-B

FIG. 2-C

Illustrating pseudarthrosis. The patient had a history of symptoms of six months' duration when fusion was done in 1924 at the age of two years. The lesion involved the second, third, and fourth lumbar vertebrae, and the fusion extended from the eleventh thoracic vertebra to the fourth lumbar vertebra, inclusive. The condition fourteen years after fusion was excellent.

Fig. 2-A: Preoperative film.

Fig. 2-B: Thirteen months after fusion, showing pseudarthrosis and increase in deformity with no subsidence of the lesion. Repair of the pseudarthrosis was done.

Fig. 2-C: Fourteen years after first fusion, showing solid fusion, bony fusion and growth of bodies, and moderate deformity.

motion their obscure ways of resisting tuberculosis, which tend toward quieting the activity of the lesion.

The primary purpose and the fundamental result expected of a spine fusion is the elimination of motion at the vertebral joints, thereby establishing a state of what is called rest in the area of the disease.

It is expected that within three weeks the fusion will be strong enough to produce the effect of rest. This effect is often demonstrable in four months. If roentgenographic evidence of a lessening of the disease activity is not present in from six to eight months, either the fusion is not solid or some of the unknown factors cited are stronger than estimated.

It is hoped that the fusion will prevent an increase in the kyphos, but this is not expected in all cases. It is not expected that a fusion of the posterior elements will hold apart vertebral bodies when an intervening one has been totally destroyed. Increase of the kyphos is expected to stop as soon as the repair tissue and the converging vertebral bodies offer a supporting strength, which, combined with the strength of the fusion, equals that of the deforming factors. This arrest of the deformity is expected to occur much sooner than it would without the fusion, and the deformity is not expected to increase thereafter. If this effect is not evident in from six to eight months, either the fusion is not solid or the disease is progressing.

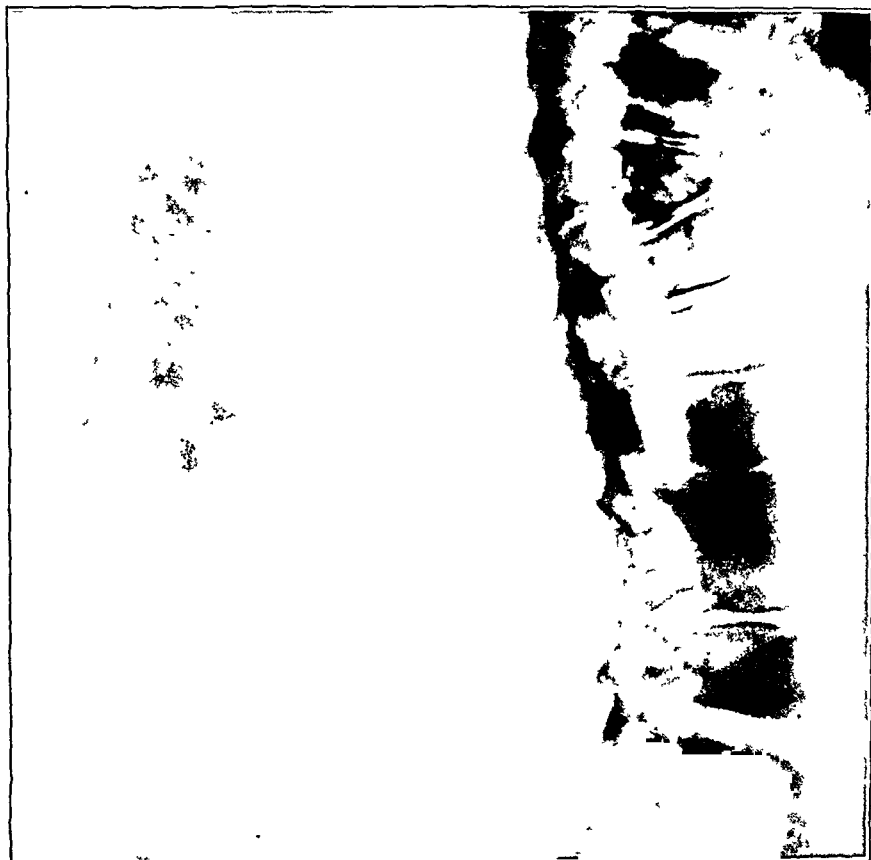


FIG. 3-A

FIG. 3-B

Illustrating control of deformity and growth of spine. The patient had a history of symptoms of one year's duration when fusion was done in 1925 at the age of three years. The lesion in the ninth and tenth thoracic vertebrae was advanced; that in the second and third lumbar vertebrae was in the early stage. A two-stage fusion, extending from the sixth thoracic vertebra to the fourth lumbar vertebra, inclusive, was done. The patient was ambulatory in five months. The condition fifteen years after fusion was excellent.

Fig. 3-A: Preoperative film.

Fig. 3-B: Eight years after fusion operations, showing solid fusion, bony ankylosis of the diseased vertebrae, no deformity, and growth of spine in the fused segment.

It is expected that paravertebral abscesses will tend to disappear if they are dependent for their contents on the activity of the vertebral lesion, which effect is frequently observed as early as the fourth month. It is not expected that a spine fusion will have any but an indirect effect on soft-tissue tuberculosis, such as abscesses and sinus tracts where tuberculosis granulation tissue is actually established in the soft tissues.

In children, it is expected that, with the cessation of tuberculous activity in the vertebral bodies, the latter will grow in height throughout the fused segment to the extent potential in the growth factors which have survived the ravages of the disease.

It is expected that, after a successful fusion, it will be safe to permit a patient to be ambulatory at a relatively early date, partly because of

the support in the fusion mass, and partly because the repair processes are expected to be well advanced.

It is expected that the repair processes once initiated after a successful fusion will continue to a point where the roentgenographic appearance of the previously diseased bone is entirely healthy, whether or not actual bony ankylosis takes place. When this point is reached, the danger of a recurrence of active tuberculosis in that area is not feared. This relatively normal appearance of the bone is the ultimate end result expected to occur after a successful spine fusion.

There is no hesitation in saying that these effects are not observed in every patient, or in recognizing that numerous complications and untoward results occur. However, as it is the purpose of this paper to emphasize briefly the demonstrable, beneficial, perhaps specific effects which do follow the majority of spine-fusion operations, particularly in young children, the complications, important as they are, cannot be discussed fully.

It should be said, however, that the two chief causes of an unsuccessful outcome after a fusion are the inability of the patient's

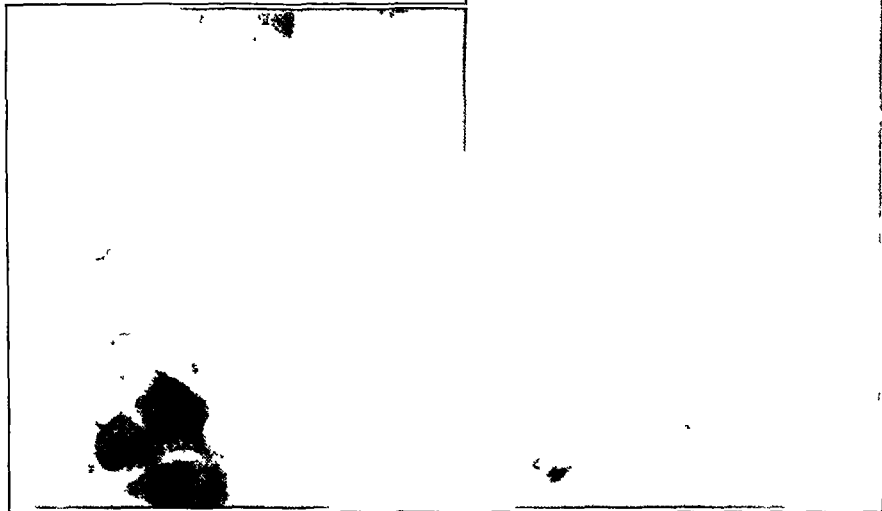


FIG. 4-A

FIG. 4-B

Illustrating course of a lumbar lesion. The patient had a history of symptoms of five months' duration when fusion was done in 1925 at the age of three years. The lesion involved the second, third, and fourth lumbar vertebrae, and the fusion extended from the twelfth thoracic vertebra to the fifth lumbar vertebra, inclusive. The patient was ambulatory in five months. The condition fifteen years after fusion was excellent.

Fig. 4-A: Preoperative film.

Fig. 4-B: Fourteen years after fusion, showing bony ankylosis of the diseased vertebrae with apparent loss of the third lumbar, slight deformity, healthy bone, and growth of the bodies in the fused segment.

tissues to resist tuberculosis and the failure of the fusion to become solid or to cover a sufficient number of vertebrae. The first cause the surgeon can do little about; the second is to a considerable extent in his hands. Should a failure of fusion be suspected, the region should be explored without delay, and, if a pseudarthrosis is found and successfully repaired, the expected sequence of effects will usually follow. It must be obvious that a fusion which is not solid can in no way fulfill the purposes for which it was performed, and that a patient whose powers of resistance are exhausted or inadequate will not respond in the expected manner.

The most important data on the end results of the patients studied are presented in the following series of tables.

TABLE I  
ANALYSIS OF MATERIAL (1911-1930) ON WHICH STUDY IS BASED

	No	Per Cent
Patients included in study	584	71 48
Patients lost before 5-year follow-up	233	28 52
Total patients operated upon	817	100 00
Patients 10 years of age and under	332	56 85
Patients over 10 years of age	252	43 15
Total patients in study	584	100 00

It is seen in Table I that 817 patients with tuberculosis of the spine were operated upon in this period and that 584, 71 per cent, have been followed for at least five years or are known to be dead. This figure is worth emphasizing, as well as the number of children in the group. If the

TABLE II  
CLINICAL DATA\*

	Ages of Patients		Combined Groups (416 Cases)
	1 to 10 Years (259 Cases)	11 Years and Over (157 Cases)	
Symptoms present less than 1 year	53 per cent	29 per cent	44 per cent
Previous treatment	33 per cent	52 per cent	43 per cent
Lesion active at fusion	83 per cent	68 per cent	77 per cent
Patient recumbent over 4 months after fusion	17 per cent	8 per cent.	13 per cent
Follow-up period of over 10 years . . .	64 per cent	54 per cent	61 per cent

\* On the patients who survived, the 168 who died not being included

children were to be divided into smaller age groups, it would be found that 160 of them were less than five years old. The youngest child who had a fusion was nine months old at the time, but, unfortunately, he was lost after having made an amazing and rapid recovery during the two years he was under observation.

Table II is based on the living patients, the 168 who died not being included. It is interesting to compare the children with the older individuals under the various headings. Previous treatment means that the patient had had some sort of so-called conservative treatment, but it is not possible to say whether or not this could be called adequate treatment except in a few instances. Of the group as a whole, 77 per cent. had active lesions at the time of fusion, while the children's percentage of activity was 83. The period of recumbency is important to note, and it will be seen that only 13 per cent. of all these 416 patients were kept in bed longer than four months after the operation. Or, conversely, 87 per cent. of the patients were ambulatory at the end of four months. At the present time the period of recumbency would be longer—six to 12 months—as it is believed that some increases in the kyphos will be prevented if the fusion has a longer time in which to solidify before the patient is allowed up. The fact that ten-year follow-up examinations have been obtained in 61 per cent. of the patients included in this study makes it clear that many observations have been made on these patients.

Table III needs little comment except to say that the number of pseudarthroses is high and indicates the need of constant vigilance to detect its presence. Eleven patients needed other operations before a solid repair of the pseudarthrosis was accomplished, and one of them, even after five attempts, still has a crack at the apex of the kyphos. It brings out also the point that one must be prepared to do a secondary fusion if the first one was too short or if the disease progresses in vertebrae which were not diagnosed originally as diseased.

There have been 168 known deaths among the 584 patients, and

TABLE III  
CAUSES OF DELAYED RESULTS

	Ages of Patients		Combined Groups (584 Cases)
	1 to 10 Years (332 Cases)	11 Years and Over (252 Cases)	
Pseudarthrosis in fusion. . . .	13 per cent.	16 per cent.	15 per cent.
Pseudarthrosis after repair		8 patients	
Third pseudarthrosis. . . .		3 patients	
Vertebrae added for short fusion. . . . .	8 per cent.	1 per cent.	5 per cent.
Fusion for new lesion in an- other region. . . . .	2 per cent.	3 per cent.	3 per cent.

TABLE IV  
CAUSES OF DEATH

	Ages of Patients		Combined Groups (168 Cases)
	1 to 10 Years (73 Cases)	11 Years and Over (95 Cases)	
Tuberculous meningitis	26 per cent.	11 per cent.	18 per cent.
Tuberculosis of lungs	7 per cent.	17 per cent.	13 per cent.
Other forms of tuberculosis	23 per cent.	21 per cent.	22 per cent.
Postoperative shock and infection	4 per cent.	5 per cent.	5 per cent.
Miscellaneous, non-tuberculous	40 per cent.	46 per cent.	42 per cent.

Table IV lists the various causes, the percentages being based on the total deaths. Again it is interesting to compare the two age groups and to note, for example, how many more of the younger patients than the older ones died of meningitis, while the opposite is true for pulmonary tuberculosis. It may be pointed out that 53 per cent. of the deaths were caused by some form of tuberculosis. This represents eighty-eight patients and means that 15 per cent. of the 584 patients died of tuberculosis.

The figures for shock and infection represent a single death in an adult from a streptococcus wound infection, four instances of true shock in adults, and three in children. Here is one of the real hazards in this treatment for tuberculosis of the spine, and yet it seems a relatively small one when compared with the tremendous benefits which have accrued to the living patients. When these eight deaths are calculated on the basis of the entire series of 584 patients, the actual operative mortality is found to have been only 1.4 per cent.

Further analysis of the deaths shows that 34 per cent. of them occurred within one year of the fusion operation; 38 per cent. of the children and 31 per cent. of the older individuals were in this group. Forty-eight per cent. of the patients who have died had relatively active lesions at

TABLE V  
RESULTS OF OPERATION IN 584 CASES

	Ages of Patients		Combined Groups (584 Cases)
	1 to 10 Years (332 Cases)	11 Years and Over (252 Cases)	
Excellent, early	54 per cent.	44 per cent.	50 per cent.
Excellent, delayed	18 per cent.	9 per cent.	14 per cent.
Failure, but patient is living	6 per cent.	9 per cent.	8 per cent.
Death	22 per cent.	38 per cent.	28 per cent.

the time of operation, as judged by the fact that they had had symptoms for less than one year, and in this group 59 per cent. were under ten years of age, while 38 per cent. were older.

Table V shows the end results of all the patients grouped according to their final clinical and roentgenographic examinations. The patients who are in good condition clinically and whose roentgenograms show the tuberculous lesion to have entirely subsided are listed as having excellent results. These results are divided under two headings, early and delayed, for the purpose of indicating the large number of patients who recovered quickly and reached an excellent condition without any complication other than perhaps some increase in the kyphos. The delayed heading represents those patients who reached an excellent condition only after some complications, which slowed their progress. Some had pseudarthroses, which were repaired; others had very active lesions, which were slow in subsiding; and a few needed secondary operations to lengthen the fusion or to take care of a new focus elsewhere in the spine. It must be emphasized that in each division the results for the children are better, and that the combined headings show excellent results in 72 per cent. of the children and 53 per cent. of the older patients.

#### SUMMARY

1. Spine-fusion operations for tuberculosis of the spine were performed on 817 patients in the twenty-year period 1911 to 1930. Seventy-one per cent. of these patients were followed for at least five years; of these, 61 per cent. were followed for periods of from ten to twenty-four years.

2. The demonstrable and expected benefits of a successful spine fusion are:

- a. Rest to the diseased area;
- b. Subsidence of the activity of the lesion at an early date;
- c. Maintenance of the kyphos at the minimum amount of deformity;
- d. Growth of the vertebral bodies in the fused area in children;
- e. Possibility of the patient's being ambulatory at an early date;
- f. Attainment of a permanent healthy roentgenographic appearance of the diseased vertebrae.

3. Excellent results were obtained in 72 per cent. of the children and in 53 per cent. of the older patients.

# TREATMENT OF TUBERCULOSIS OF THE SPINE

BY MATHER CLEVELAND, M.D., NEW YORK, N. Y.

An attempt to study a single manifestation of a disease so protean as tuberculosis is difficult and perhaps unwise. One excuse for selecting the invasion of the vertebrae and the intervertebral joints by tuberculosis may be the relative frequency of this lesion. The weight-bearing joints are involved in about 95 per cent. and the vertebral joints in 52 per cent. of all instances of joint tuberculosis.

This discussion is based on 173 consecutive cases of tuberculosis of the spine treated surgically at Sea View Hospital from 1924 to 1934, inclusive, and thirty consecutive cases from St. Luke's Hospital similarly treated from 1930 to 1938. In the time allowed, only the barest details can be presented, and an attempt will be made to answer certain categorical questions asked by the Chairman.

It is my belief that the answer to the problem of joint tuberculosis, including tuberculosis of the spine, lies not in methods, techniques, surgical procedures, alpine sunlight, etc., but in more fundamental and often ignored factors,—that is, the extent of invasion by the tubercle bacillus and the patient's reaction to this disease. An attempt to classify these patients according to the severity of the infection has been previously presented, but it is necessary to repeat this to clarify the argument. There are four groups ranging from minimal to maximal involvement by the disease:

*Group A: Patients with no evidence of pulmonary tuberculosis.* This, an easily recognized group, consisted of seventy patients, 34.48 per cent. of the whole number, with tuberculosis of the spine but no pulmonary involvement. The mortality was 11.42 per cent. Death in this group usually occurs from prolonged suppuration and attendant amyloid disease.

*Group B: Patients with pulmonary tuberculosis and negative sputum, but with no metastatic spread to other organs.* There were fifty-six patients in this group with arrested pulmonary disease. During their hospital stay their sputum examination had always been negative. Their mortality was 7.14 per cent.

*Group C: Patients with pulmonary tuberculosis and positive sputum.* There were forty-five patients who had positive sputum at some time or throughout their hospital stay. They showed a mortality of 44.44 per cent.

*Group D: Patients with pulmonary tuberculosis and negative sputum, and with metastatic spread to other organs.* This group of thirty-two patients, in whom metastatic spread of the disease developed, showed a mortality of 68.75 per cent. For the most part they were overwhelmed by the disease and predestined to failure to survive. Such patients are apt to have invasion of gastro-intestinal or genito-urinary tracts or lymph glands,



and often miliary tuberculosis ultimately develops. There is no certain means of recognizing patients in this group until they have declared themselves definitely. Once they are established in Group D, it is foolhardy to attempt any surgery except of a palliative nature. Having watched the development of metastatic spread in these patients in the wards prior to any surgery, I doubt very much if the surgical procedure plays any part in dissemination of the disease.

Since Groups A and B showed a combined mortality of 9.52 per cent., and Groups C and D showed a mortality of 54.54 per cent., it must be obvious that the success or failure of any type of treatment, in a given series of cases, will depend upon which groups form a majority of the patients in that series. (See Table I.)

### *Duration of Symptoms*

For the entire group of 203 patients, the average time between the onset of symptoms and the operative treatment was over three years. Rarely is the disease recognized in these patients within six months of onset, and it takes a much longer time for them to come under the care of an orthopaedic surgeon. Only 15 per cent. of the Sea View patients were admitted within a year of onset, while at St. Luke's Hospital, 50 per cent. were seen within a year and 16 per cent. within six months of onset. The importance of earlier recognition and treatment of these patients should be emphasized.

TABLE I

MORTALITY IN RELATION TO EXTENT OF SYSTEMIC TUBERCULOUS INFECTION IN  
203 PATIENTS WITH TUBERCULOSIS OF THE SPINE

Group	Sea View Hospital			St. Luke's Hospital			Entire Group		
	Patients (No.)	Deaths (No.)	Mortality (Per Cent.)	Patients (No.)	Deaths (No.)	Mortality (Per Cent.)	Patients (No.)	Deaths (No.)	Mortality (Per Cent.)
A: Patient with no evidence of pulmonary tuberculosis	52	7	13.46	18	1	5.55	70	8	11.42
B: Patients with pulmonary tuberculosis and negative sputum, but with no metastatic spread to other organs	50	4	8.00	6	0	0.00	56	4	7.14
C: Patients with pulmonary tuberculosis and positive sputum	40	18	45.00	5	2	40.00	45	20	44.44
D: Patients with pulmonary tuberculosis and negative sputum, and with metastatic spread to other organs	31	21	67.74	1	1	100.00	32	22	68.75

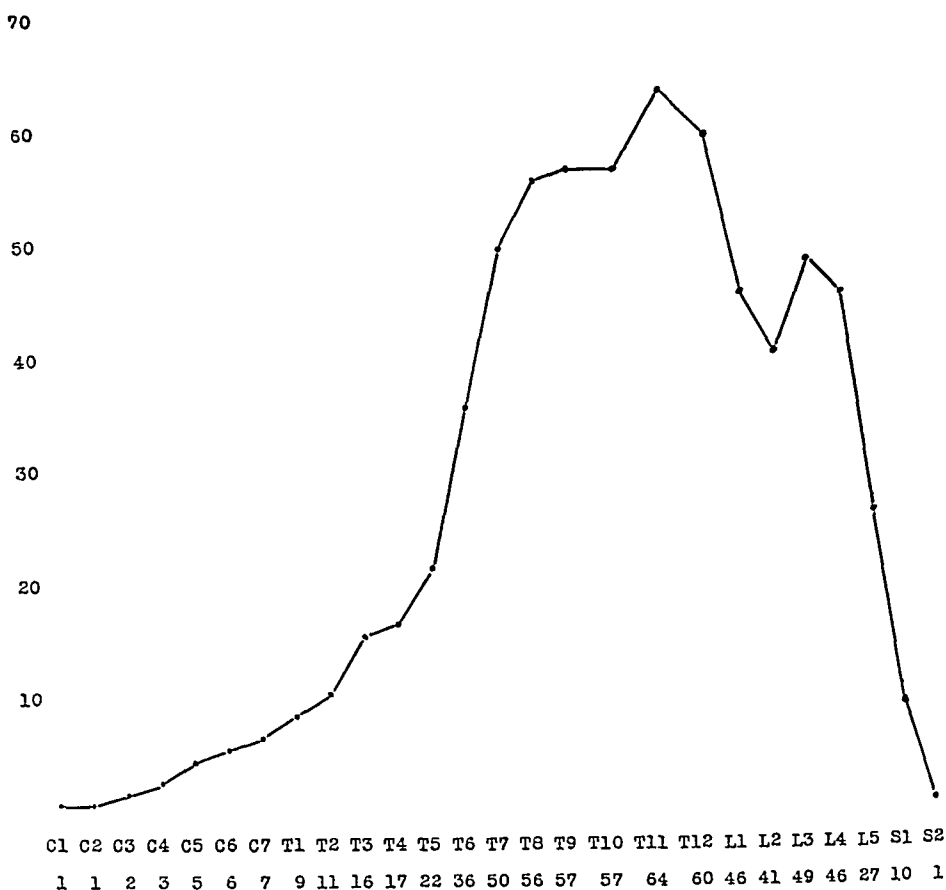


CHART 1

Vertebrae involved in the series of 203 patients operated upon.

I shall take no time to discuss the subject of diagnosis of tuberculosis of the spine except to say that it is not always simple and that the classic pattern of physical signs and roentgenographic evidence is not always followed.

### *Area of Spine Involved*

These patients showed involvement of every vertebra from the atlas to the sacrum. The vast majority of the lesions were in the lower thoracic and upper lumbar vertebrae. (See Chart 1.)

### *Paraplegia*

Spinal-cord pressure, caused by an extradural abscess, varies from slight spasticity with hyperactive reflexes to complete paralysis with anaesthesia and loss of control of anal and urinary sphincters. This occurs in all age groups. There were forty-eight of these 203 patients who gave evidence of spinal-cord compression. Of these, seventeen showed mild or incomplete compression, which cleared up rather quickly with rest in bed. The remaining thirty-one, who gave evidence of serious

spinal-cord compression with complete paraplegia, presented a graver problem. In thirteen of these thirty-one, or 41.93 per cent., the paraplegia developed prior to operation; in eighteen, or 58.06 per cent., the paralysis developed following operation, in periods of time varying from six months to several years after the surgical procedure. Of these thirty-one completely paralyzed patients, seventeen recovered their motor power and survived the disease. Of the fourteen who failed to recover from the paraplegia, all but one have died of the disease,—a mortality rate of 41.93 per cent. for those patients with complete paraplegia. Although prior to 1930 a number of laminectomies were performed on these patients, we now feel that surgical fusion of the spine and prolonged bed rest offers the best means of treatment. Paraplegia is found most frequently in patients with disease of the thoracic spine. The apex of maximal involvement in these forty-eight patients was at the seventh and eighth thoracic vertebrae. (See Chart 2.)

#### *Abscesses*

Paravertebral, mediastinal, or psoas abscesses are present in a very high percentage of these patients. Abscesses were noted in 68 per cent. of the Sea View patients. Because of this high frequency, the patients in the smaller St. Luke's series were carefully checked for this condition.



FIG. 1-A  
January 28, 1932

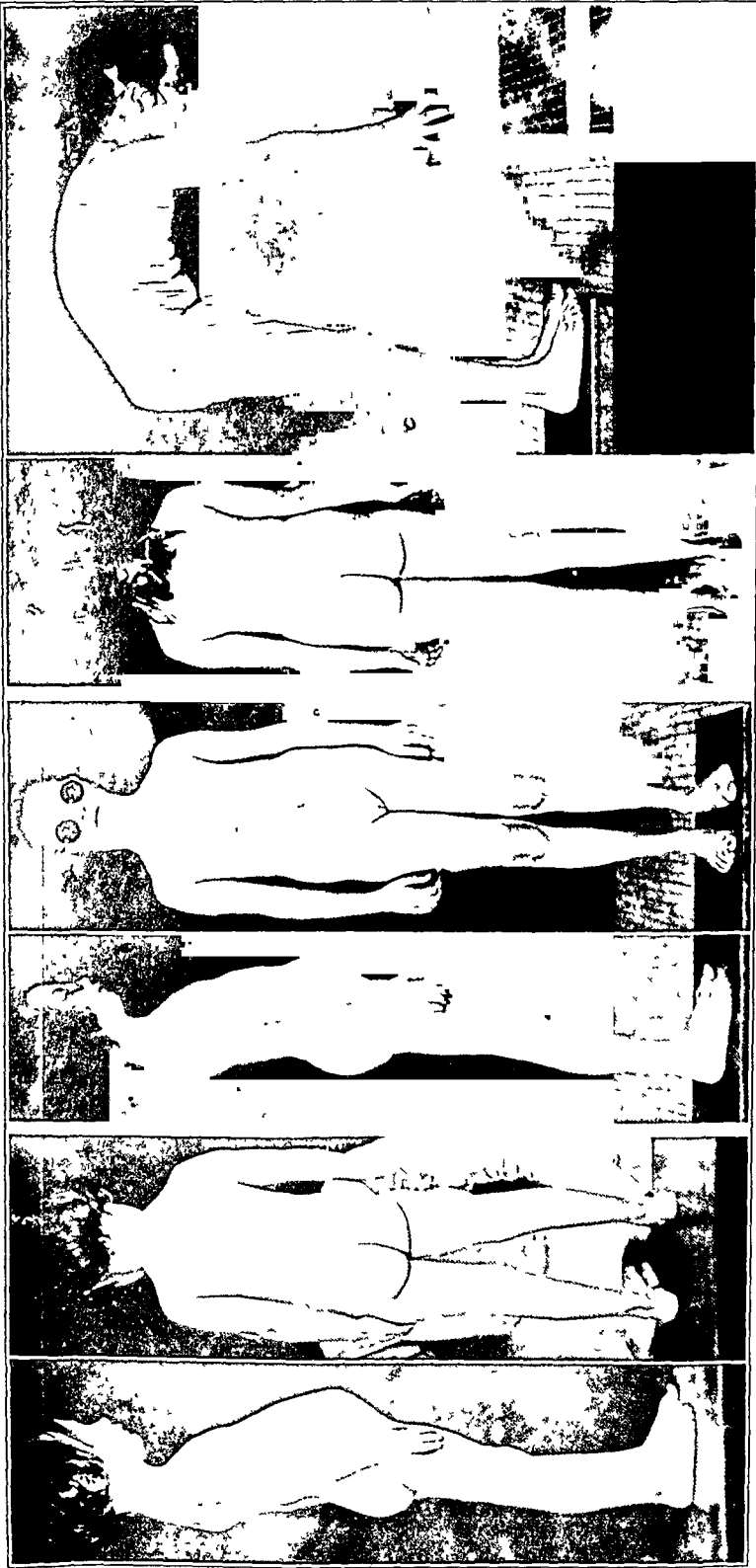


Fig. 1-B  
January 28, 1932

Fig. 1-C  
January 26, 1939

Fig. 1-D  
June 8, 1939

Case 1. J. D. (St. Luke's Hospital, No. A12248), a girl, four years of age, was seen in December 1931, with tuberculosis of the first and second lumbar vertebrae. On January 29, 1932, a fusion, extending from the twelfth thoracic vertebra to the fourth lumbar vertebra, inclusive, was carried out. The patient spent twelve months in bed, and during the postoperative course the fifth lumbar vertebra was added to the fusion, making a total fusion of six vertebrae. The final follow-up examination on January 26, 1939, showed solid fusion, clinically and roentgenographically, and the patient was in excellent health. This is an eight-year result. Preoperative photographs and roentgenograms and those taken at the latest follow-up (Fig. 1-E) are shown for comparison.

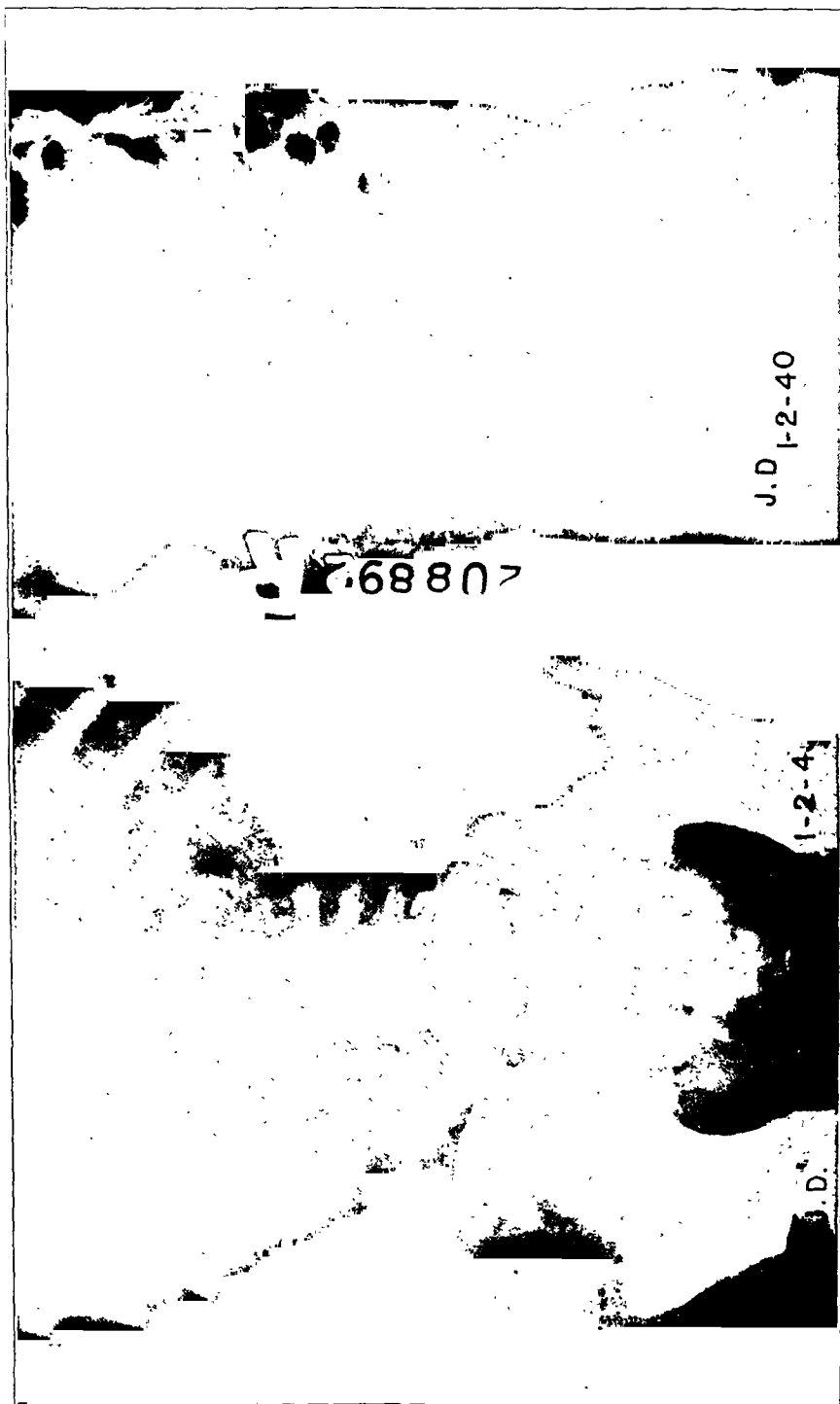


FIG. 1-E  
January 2, 1940

Only 23 per cent. showed clinical evidence of an abscess, while 80 per cent. showed roentgenographic evidence. In addition to this, post-mortem examination in two cases revealed an abscess which had not been discovered either by clinical or by roentgenographic means. This made the

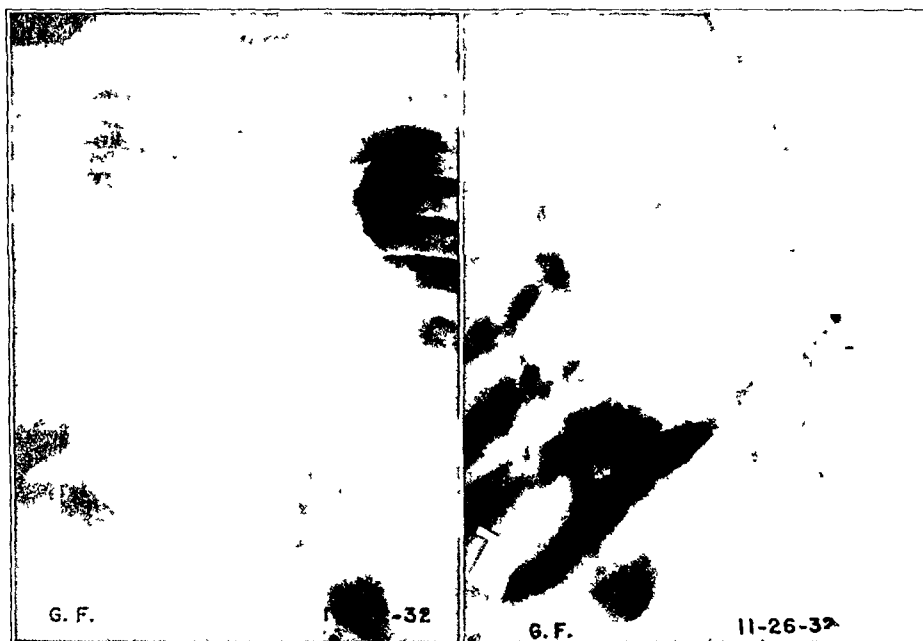


FIG. 2-A  
November 26, 1932

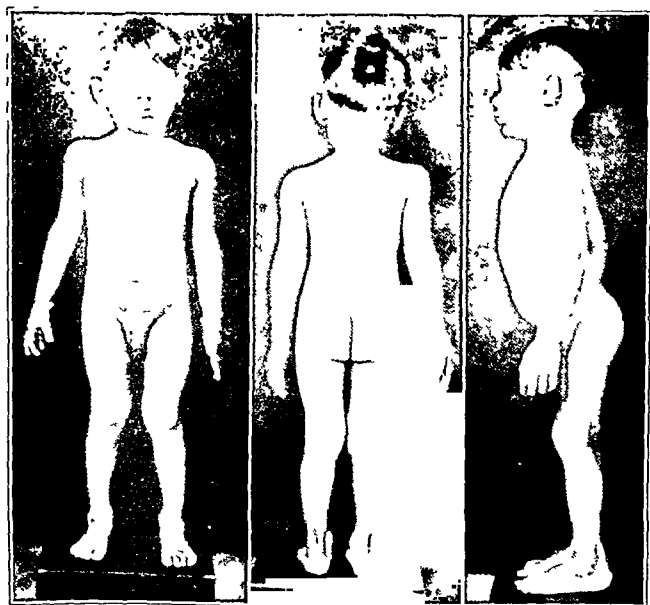


FIG. 2-B  
December 8, 1932

Case 2. G. F. (St. Luke's Hospital, No. A20876), a boy, three years of age, was seen in November 1932, with tuberculosis of the sixth and seventh thoracic vertebrae, which later extended to include the fifth and eighth thoracic vertebrae. On December 9, 1932, a six-vertebrae fusion, from the fourth thoracic vertebra to the ninth thoracic vertebra, inclusive, was done. The patient was kept in bed for a total of eleven months at St. Luke's Hospital and St. Luke's Convalescent Hospital; his total hospital stay was fifteen months. The latest follow-up examination, on June 3, 1939, showed solid fusion, clinically and roentgenographically—an excellent result, six and one-half years after operation.

Preoperative photographs and roentgenograms, and those taken at the latest follow-up are shown for comparison.

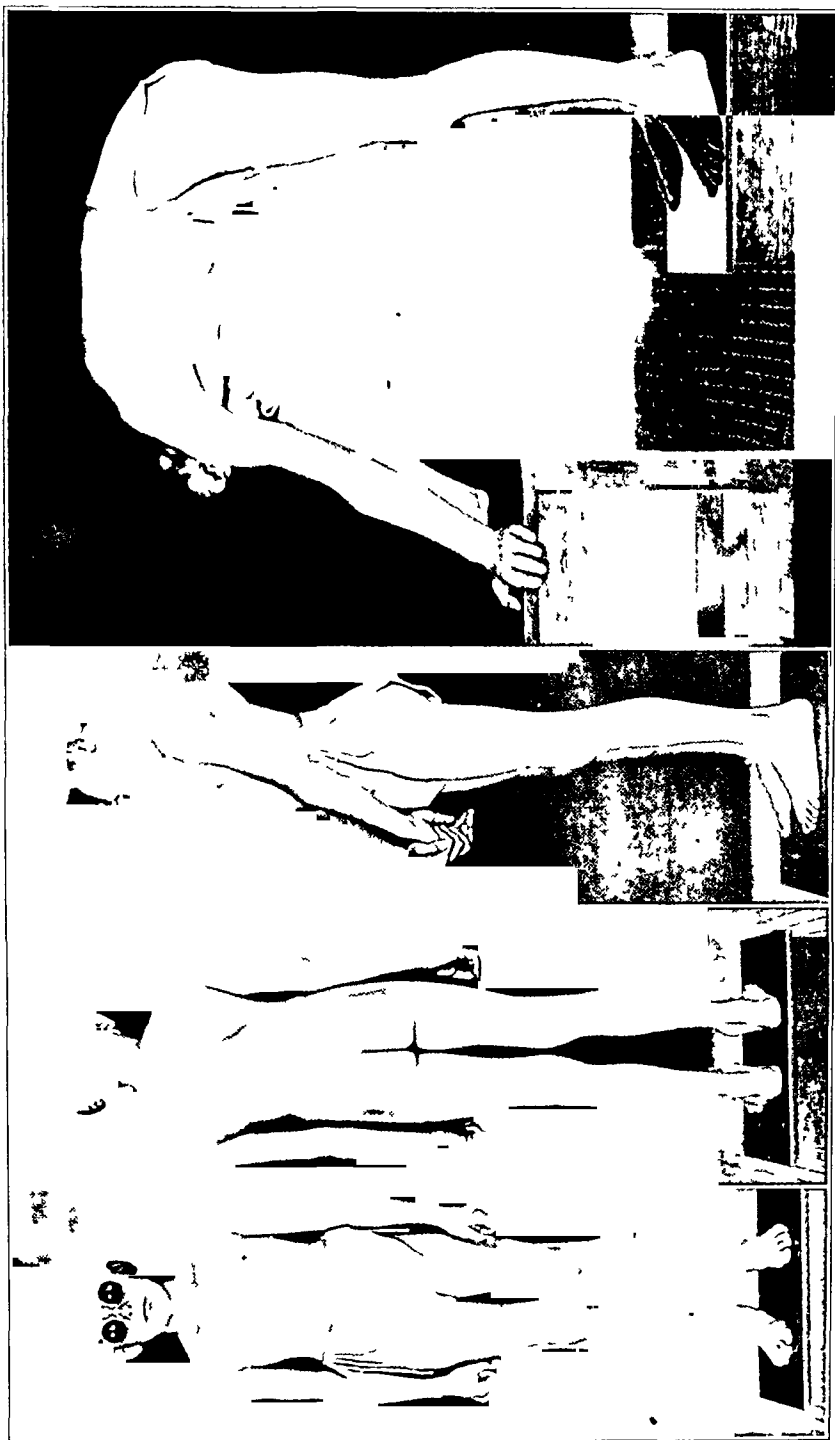


FIG 2-C  
June 3, 1939



FIG. 2-D  
June 3, 1939

known incidence of abscess 86 per cent. While suppuration is a major phenomenon of this disease, only a small number of the abscesses required treatment. Repeated aspiration is the treatment of choice, although incision and drainage with suture of the wound may be necessary.

The stage beyond the abscess shows clinically the presence of a sinus, which may have occurred spontaneously or may have been the result of heedless surgery. The sinus, of course, predisposes to secondary infection, prolonged suppuration, and, at times, death from amyloid disease. Twenty-two per cent. of the Sea View patients had sinuses, and of these over 50 per cent. have died. At St. Luke's Hospital, only 13 per cent. of the patients had sinuses; in all but one case the sinuses healed, and the patients recovered from the disease and had excellent results. The patients who recovered belonged in Group A, so once again the fate of the patient is seen to be controlled by intrinsic factors already mentioned rather than by extrinsic infections.

### *Spontaneous Fusion*

Since spontaneous fusion of the vertebral bodies and laminae constitutes a criterion of healing in patients who are treated by so-called conservative measures, it is quite proper to consider this phenomenon in some detail. In my experience, the spine is the only joint invaded by tuberculosis which shows this attempt at reparative process. Forty-eight



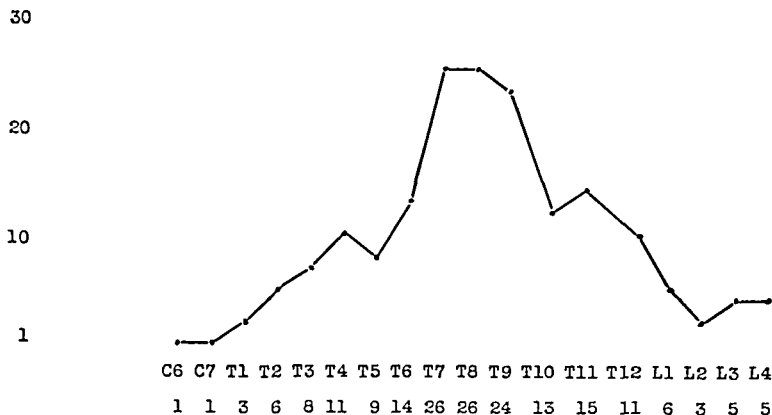


CHART 2

Vertebrae involved in the forty-eight patients in whom paraplegia developed.

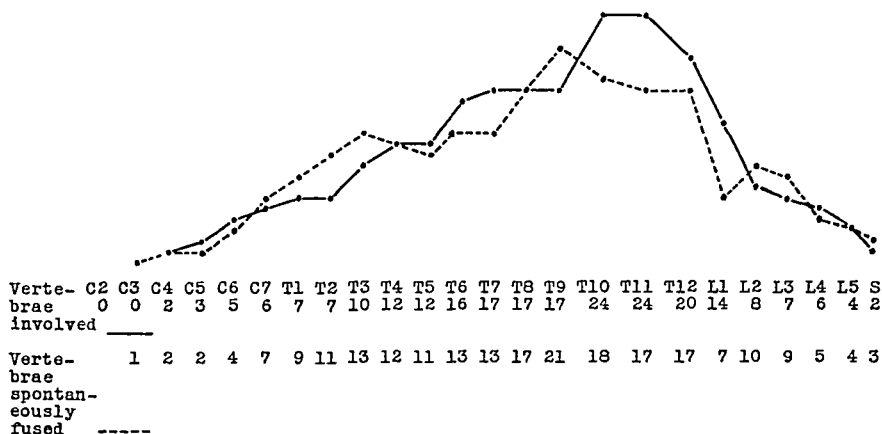


CHART 3

Spontaneous fusion, showing in a total of forty-eight patients the relation between vertebrae involved in the disease and those spontaneously fused. The broken line designates the vertebrae spontaneously fused, while the continuous line designates those involved by the disease. The total number of vertebrae spontaneously fused, 226, is less than the number of vertebrae involved by the disease, 240.

of these 203 patients, or 23.64 per cent., showed some spontaneous fusion. The average duration of the disease prior to operation in these forty-eight patients was six years and nine months, which is over twice as long as the average duration for all patients. These patients with spontaneous fusions fall into two groups: (1) those patients with a long, sharp kyphos with massive vertebral destruction in whom operation revealed an average spontaneous fusion of five or six vertebrae (this group forms the great majority of those patients with spontaneous fusion); and (2) those patients with a mild kyphosis and spontaneous fusion of two or three vertebrae (a much smaller group). The longest spontaneous fusion encountered was twelve vertebrae. Chart 3 shows the relation between the vertebrae spontaneously fused and those involved in the disease. Since there were 240 diseased vertebrae in these forty-eight patients and 226

vertebrae which spontaneously fused, one can readily appreciate that the disease is ahead of the reparative process. Spontaneous fusion requires many years and usually entails serious deformity of the spine, and in the end these patients are not adequately protected against the disease.



FIG. 3-A  
June 7, 1933

# TREATMENT

The surgical treatment of these 203 patients has been fusion of the spine of the Hibbs type with a number of minor variations in technique. Frequently additional bone is taken from the ilium and occasionally from the tibia to reinforce the area. The function of this operative intervention is to secure early and adequate immobilization by an intrinsic brace of solid bone. In principle, it follows the accepted treatment for tuberculosis in general,—rest. The diseased area is put at complete and permanent rest, if the operative technique is successful. To consider the fusion of the diseased spine as a cure is quite erroneous. Its function is purely that of mechanical support. All

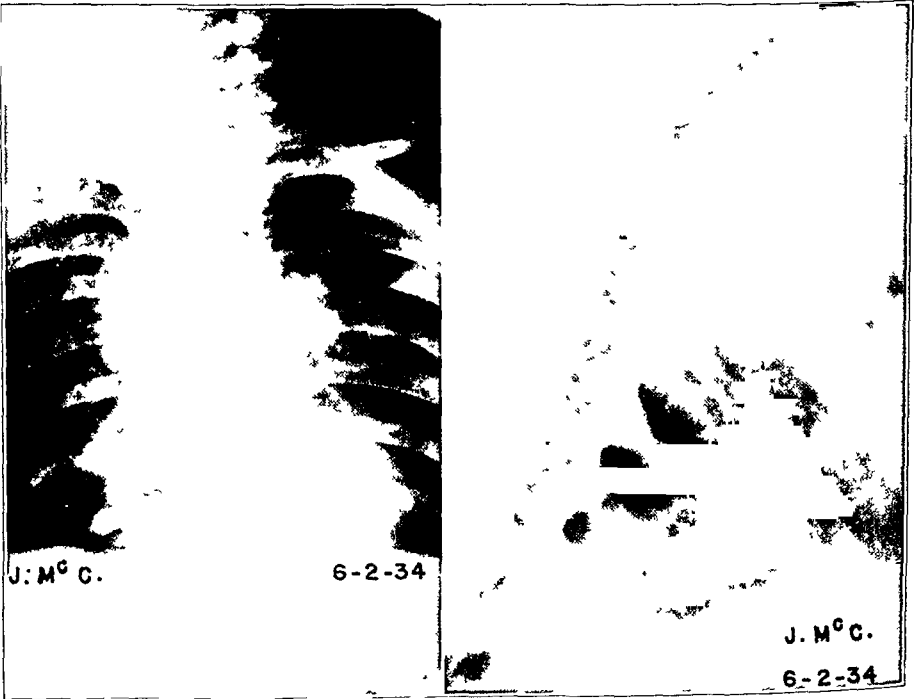


FIG. 3-B  
June 2, 1934

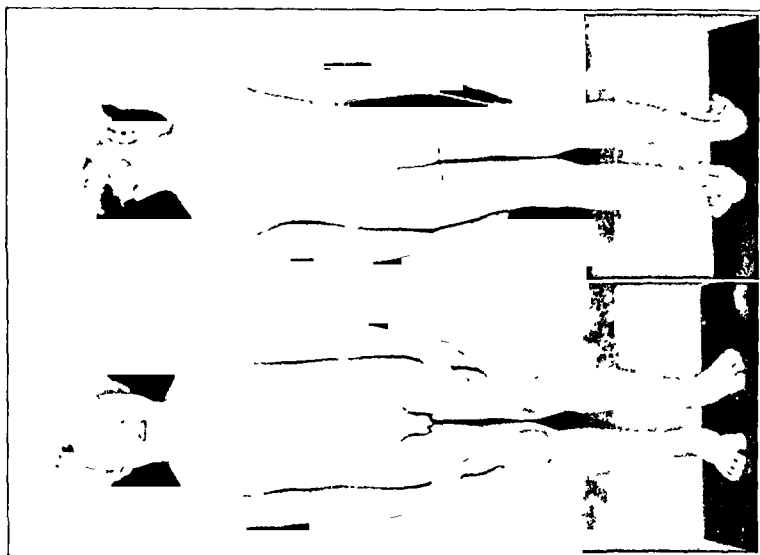


FIG. 3-D  
May 24, 1938

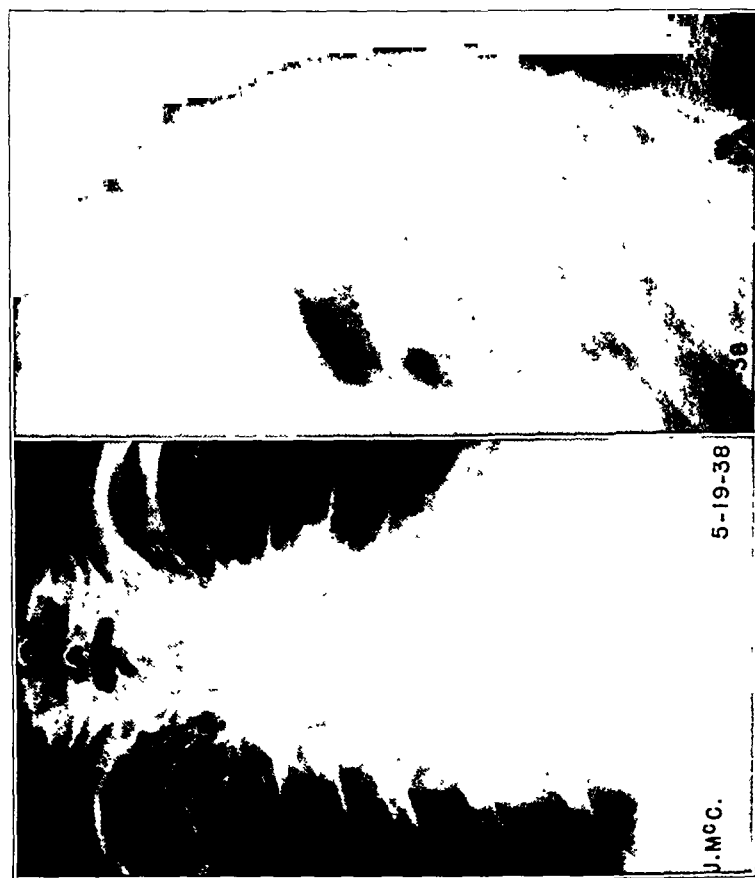


FIG. 3-C  
May 19, 1938

CASE 3. J. McC. (St. Luke's Hospital, No. 99869), a boy, eighteen months of age, was seen in June 1934, with tuberculosis of the sixth and seventh thoracic vertebrae. A fusion of the thoracic spine, extending from the fourth thoracic vertebra to the ninth thoracic vertebra, inclusive, was performed on June 11, 1934. The patient was kept in bed for nine months at St. Luke's Hospital and at the Convalescent Hospital, and his entire hospital stay was eighteen months. The preoperative photograph, which was taken in June 1933, shows markedly positive tuberculin reaction. This was during a period of hospitalization when the patient was a known tuberculosis-contact case. It was not until six months later that symptoms in his spine developed and one year later that the fusion was done. This patient shows an excellent result four years after operation. Preoperative photographs and roentgenograms and those taken at the latest follow-up are shown for comparison.

TABLE II  
AGE INCIDENCE IN PATIENTS WITH TUBERCULOSIS OF THE SPINE

Age (Years)	Sea View Hospital (Cases)	St. Luke's Hospital (Cases)	Total (Cases)
1 to 10	33	10	43
11 to 20	27	6	33
21 to 30	50	4	54
31 to 40	28	4	32
41 to 50	23	3	26
51 to 60	10	3	13
Over 60	2	0	2
Total	173	30	203

the various supportive measures must be used with bed rest for nine to eighteen months after operation. The fusion by surgery accomplishes in from six to nine months what it takes nature from five to six years to achieve.

Because of inability to detect roentgenographically very early manifestations of vertebral invasion by tuberculosis, it is preferable to extend the fusion from two apparently sound vertebrae above the diseased area to two similar vertebrae below. This usually means a minimal fusion of six vertebrae. Longer fusions may have to be done in two or more stages. We have a good many satisfactory four-vertebrae fusions, which have arrested the disease. A plaster jacket or brace helps to ensure certainty of success.

The argument is frequently offered that, while fusion of the spine for adults with vertebral tuberculosis may be a suitable form of therapy, it is

TABLE III  
ANALYSIS OF DEATHS IN RELATION TO AGE

Age (Years)	Sea View Hospital			St. Luke's Hospital			Entire Group		
	Patients (No.)	Deaths (No.)	Mortality (Per Cent.)	Patients (No.)	Deaths (No.)	Mortality (Per Cent.)	Patients (No.)	Deaths (No.)	Mortality (Per Cent.)
1 to 10	33	3	9.09	10	1	10.00	43	4	9.30
11 to 20	27	8	29.62	6	1	16.66	33	9	27.27
21 to 30	50	17	34.00	4	0	0.00	54	17	31.48
31 to 40	28	10	35.71	4	1	25.00	32	11	34.37
41 to 50	23	7	30.43	3	0	0.00	26	7	26.92
51 to 60	10	5	50.00	3	1	33.33	13	6	46.15
Over 60	2	0	0.00	0	0	0.00	2	0	0.00
Total	173	50	28.90	30	4	13.33	203	54	26.60

TABLE IV  
END RESULTS OF TUBERCULOSIS OF THE SPINE IN 203 CASES

Rating	Patients	Per Cent.	Average Time After Operation
Sea View Hospital—173 Cases:			
Excellent	91	52.60	3 years, 9½ months
Uncertain	32	18.49	2 years, 8 months
Died	50	28.90	14 months
St. Luke's Hospital—30 Cases.			
Excellent	19	63.33	4 years, 9½ months
Uncertain	7	23.33	2 years, 7 months
Died	4	13.33	11 months
Total—203 Cases:			
Excellent	110	54.18	3 years, 10 months
Uncertain	39	19.21	2 years, 8 months
Died	54	26.60	13½ months

quite unsuitable, not to say dangerous, for children. There is nothing in our experience to justify such a point of view, and there is a great volume of evidence to contradict it. Of these 203 patients treated surgically, 37.43 per cent. were under twenty-one years of age and 21.18 per cent. were in the first decade of life (Table II). The disease is essentially one of childhood, adolescence, and early adulthood. It is interesting to note that the children under ten showed a mortality of only 9.3 per cent. (Table III). Of the forty-three patients under ten years of age, there were thirteen under five. Among these infants were found some of our very best results. Fusion, which takes place rapidly in these youngsters, saves them years of hospitalization during the most important period of their lives. It retards deformity, although in the thoracic spine it will not prevent a kyphos. In this area, the deformity tends to increase until diseased vertebrae settle into contact with sound vertebrae above and below. Fusion does not retard growth, as may be seen by careful study of roentgenograms. Any loss in height depends upon the amount of vertebral destruction. The average rate of growth for our children operated upon before the age of five years has been a little over two inches per year for a five-year period. The average for the normal child during this same period is a little under two inches per year.

### *Pseudarthrosis*

Among these 203 patients, there were successful fusions at the first operation in 176 instances, or 86.69 per cent. Known failure of fusion, which was repaired, was present in 7.4 per cent., and 6 per cent. of the patients can only be classified as unknown in regard to certainty of fusion. Some of these left the hospital within a few months after operation, and their records are incomplete. It is altogether likely that an incidence of at least 10 per cent. of failure of fusion may be expected in the hands of

experienced surgeons, and that with lesser experience the incidence will be higher.

#### END RESULTS

The estimation of end results in this chronic, insidious disease is difficult and disappointing. After years of quiescence the patient may present evidence of virulent infection with tuberculosis, while the local joint lesion has been forgotten. To speak of these patients as being cured is almost as dangerous as it is to consider a cancer patient cured. We can speak of five-year and ten-year results, but always with some reservation. For a number of years we have used a simple classification which is not rigid and is, of course, open to criticism:

*Excellent:* Those patients with solidly fused spines, but with no active pulmonary disease, who have left the hospital to resume a relatively normal life.

*Uncertain:* Those patients with solidly fused spines, but with active pulmonary disease, metastatic spread, or prolonged suppuration. Some of these are still hospitalized, while many have left the hospital. There is no feeling of security for their future.

*Died:* Concerning this group there is no argument, as it includes all those who died of tuberculosis.

Each time these patients are subjected to recall for study, some changes in rating are noted. In the most recent study, the following changes occurred. In the excellent group there were five changes: Three patients formerly considered excellent must now be rated uncertain, because of renewed activity of the disease; and two have died of the disease, each six years after operation, completely symptom-free as far as their spines were concerned. In the uncertain group, one patient has died and two patients have been promoted to the excellent group, six years after operation. These illustrations are cited to show the difficulties encountered in attempting to state categorically end results for these patients whose conditions fail to remain static.

The great majority of our patients were operated upon at Sea View Hospital on Staten Island. This Hospital has no out-patient department, and on discharge the patients scatter through the five boroughs of the city. Many are transients, and they all move frequently. Often they are lost to follow-up. Of these 173 Sea View patients we have a 60 per cent. follow-up to date. At St. Luke's, in the smaller series, we have a 90 per cent. follow-up to date. The end results in these 203 cases (Table IV) are as follows:

*Excellent*, in 54.18 per cent., followed for an average of three years and ten months.

*Uncertain*, in 19.21 per cent., followed for an average of two years and eight months.

*Died*, in 26.6 per cent., at an average of thirteen and one-half months after operation. The smaller St. Luke's series shows 63.33 per cent. with

excellent results and 13.33 per cent. who died. This is explained by the far higher incidence of St. Luke's patients in Groups A and B.

In response to certain other categorical questions propounded by the Chairman, I shall answer as follows:

1. *Five-year results:* There are fifty patients who have been followed for five years or more. Two of these have died, each six years after operation. The remaining forty-eight have excellent results and have been followed for an average period of slightly more than seven years.

2. *Healing of vertebral lesions:* This is accomplished by fusion either of the vertebral bodies or of the laminae with recalcification of the diseased bodies and subsidence of clinical symptoms. The diseased vertebrae tend to settle together until sound or recalcified bodies are in contact.

3. *Factors responsible for healing:* The patient's general reaction to tuberculosis is, we believe, the most important single factor in healing. If he falls into Groups A and B, his chances of healing are excellent; if he belongs to Group C, his chances are fair or worse; and, finally, if he falls into Group D, his chances are poor.

4. *Cause of death:* This is usually tuberculosis.

5. *Relapses:* In a small group of fifty patients with excellent results, with an average follow-up of seven years, only two, after six years, have died of tuberculosis.

#### CONCLUSIONS

I believe that surgery offers a chance to rehabilitate these seriously ill patients in a shorter time than any other method. Spontaneous fusion requires, on an average, over six years.

The mortality in this disease is high,—26.6 per cent. in the 203 consecutive patients in this series.

With adequate surgery, a high percentage of excellent results and a low mortality may be expected in patients in Groups A and B.

Patients with positive sputum in Group C present a definite risk. Every effort should be made to control the pulmonary disease before surgery may be reasonably attempted.

Patients in Group D, who have declared their group by definite evidence of metastatic spread, have a mortality of almost 70 per cent., and no surgical treatment other than emergency measures to relieve pain should be attempted.

In this series, 62 per cent. of our patients were in the more favorable Groups A and B. The 38 per cent. in Groups C and D were carefully selected for surgery. This should be borne in mind, as any indiscriminate selection of patients for surgery from these less favorable groups will result in an appalling mortality.

# TUBERCULOSIS OF THE SPINE: TREATMENT AND RESULTS

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Our recognition of the fact that tuberculosis of the spine is a secondary focus of a generalized disease has influenced our attitude in the treatment of the condition by means of surgical fusion. We consider surgical fusion as an aid in the treatment, not a cure, and have emphasized the paramount importance of prolonged recumbency, heliotherapy, fresh air, and abundant good food. Our patients have frequently shown tuberculous involvement of other organs of the body, especially of the lungs; abscess formation and spinal cord irritation, with or without sinus formation, have at times complicated the treatment and affected the results obtained. Although we have made a diagnosis of tuberculosis of the spine in 2080 patients during the twenty-three-year period from 1912 to 1934, inclusive, we have performed surgical fusion for only 480 patients, or 23 per cent. In this group of 480 patients, the average age was more than thirty years, and the average duration of symptoms was 2.5 years; more than 50 per cent. of these patients had not had previous treatment. Thus, this constitutes a series of cases that differ in type from those reported by some authors working in other orthopaedic centers. Of our 480 patients, only 4 per cent. were children, operation having been carried out principally during the earlier years of our experience. Only rarely do we perform operation for fusion of the spine in children now, as we prefer to carry out conservative measures.

In 1911, the reports made by Albee and Hibbs were enthusiastically received by the profession, and many surgeons, no doubt, believed that surgical fusion would quickly cure the condition without the necessity of the usual careful and prolonged conservative treatment. As the experience of the profession grew, however, a gradual change of attitude became evident, especially among those physicians whose practice was principally among children. As time passed, reliable observers reported the results of their treatment in surgical and non-surgical cases. In 1916, Henderson stated: "For some unknown reason, transplantation of bone is not so uniformly successful in children as it is in adults." Girdlestone, in 1919, was enthusiastic about the benefits of Albee bone grafts. Platt stated that the results had been better in the adult patients treated by this method than in the children so treated; McMurray thought that use of the graft was ideal for the adult patient, especially in the lumbar region of the spine, but he used conservative treatment for children. In 1927, Kidner and Muro reported the results of a comparative study of seven patients for whom operative treatment had been carried out and of seven for whom the treatment had been conservative; they concluded that the period of healing



was of the same length in both groups, and they discontinued performing surgical fusion unless there was some special indication for it. Kidner and Muro then returned to treatment by means of the Bradford frame, which was used until healing had occurred. The after-care of those patients for whom surgical fusion had been performed was practically the same as for those for whom conservative measures had been used, and these authors felt that any shortening of the period of convalescence was not worth while, and that the spines of the patients not operated upon showed more flexibility than those of patients who had had fusion operations. Later, other authors went further and said that operation to produce fusion of the spine delays healing of the tuberculosis (Cato, in 1937; McKee, in 1937; and Finkelstein, Jahss, and Mayer, in 1938).

In 1927, Allison and others abandoned surgical fusion as a therapeutic measure for tuberculosis of the spine in children. Calvé, Kleinberg, and the Commission of the American Orthopaedic Association in 1920, as quoted in 1935 by Compere and Jerome, concluded that operation to produce surgical fusion of the spine is best after prolonged conservative treatment and quiescence of the disease. Fusion of the spine was then considered by many as a useful splint to be applied internally as an aid in the healing process, the healing being judged from the roentgenograms (Rollier). Albee has expressed the belief that surgical fusion should be performed for all patients, if the risk is not too great; that vascularization of the graft carries an increased blood supply to the diseased region and thus aids in the healing process; and that paraplegia, paravertebral and psoas abscesses, fever (unless from secondary infection), a second focus of tuberculous infection, and drainage away from the field of operation are not contra-indications to operation.

In 1936, Calvé and Galland stated: "The evolution of Pott's disease lasts a little more than three years. Throughout this period, the patient must remain recumbent, rigorously immobilized upon the plaster bed. . . . This procedure [osteosynthesis] should be carried out only at the end of treatment. . . . If the operation is performed earlier, it interferes with the process of consolidation of the posterior segments of the vertebrae. . . . It delays the evolution of the disease, but does not arrest it. It does not prevent increase of gibbus, formation and persistence of abscess, or paraplegia." In 1935, in his Hunterian Lecture, Seddon stated: "When a number of vertebrae have been destroyed, angulation begins early and continues for years. No external form of fixation will prevent this if the patient is active and in children grafts are ineffective. It is difficult to hold the head and chest by posterior fusion when acute angulation has occurred." Seddon believed that rest in hyperextension and traction are useful; and when destruction has ceased and recalcification and improvement in definition of bone has occurred, when the bones have fallen together, and when compensatory curves have developed and the disease has become quiescent, surgery may be useful. Compere and Jerome, in 1935, reported a series of fifty-six cases, in twenty-eight of

TABLE I  
DISTRIBUTION ACCORDING TO AGE AND SEX

Age (Years)	Patients	Per Cent.
0 to 9.....	19	3.96
10 to 19.....	29	6.04
20 to 29.....	215	44.79
30 to 39.....	133	27.71
40 to 49.....	67	13.96
50 to 59.....	17	3.54
Total.....	480	100.00
Sex	Patients	Per Cent.
Male.....	299	62.29
Female.....	181	37.71
Total.....	480	100.00

which the patients were less than twelve years of age. These authors believed that operation gives adequate support to the spine of a child provided enough bone is used,—that is, if two vertebrae above and two below the region of involvement are included; furthermore, if there is no deformity before operation, it does not develop after operation.

Time does not permit further review of the divergent opinions on the subject or discussion of the factors involved, yet it would appear to me that the chronicity of the disease and its general character demand conservative treatment in all cases, especially in those in which there is a low resistance. Whenever progressive tuberculous invasion has occurred, the prognosis is uncertain at best for several years, and the condition may progress until there are abscesses, paraplegia, sinus formation, deformity, and even death, whether or not operation is performed. The facts that operation aids in immobilization of the spine, that patients and relatives cooperate better when surgical treatment has been given, that most orthopaedic surgeons agree that fusion is advisable as an aid in strengthening the healed tuberculous spine, and that operation can be performed without prohibitive risk would appear indicative of its usefulness. If we wait until the spine has healed and then operate, we are sure to obtain excellent results, and the usual complications and mortality rate will have been agreeably lessened.

The distribution of age and sex in the 480 cases under consideration is recorded in Table I. There was a family history of tuberculosis in 16 per cent. of the cases and no such history in 84 per cent. There was a history of trauma to the spine in 123 cases, or 25.6 per cent. The pre-

TABLE II

SITES OF TUBERCULOSIS IN CASES WITH POSITIVE HISTORY (241 PATIENTS, 50.2 PER CENT. OF TOTAL CASES)

Sites	Patients	Per Cent.
Lungs.....	113	46.89
Peritoneum.....	7	2.90
Spine.....	17	7.05
Other joints.....	15	6.23
Abscess.....	14	5.81
Genito-urinary tract.....	20	8.30
Lymph nodes.....	6	2.49
Multiple.....	49	20.33
Total.....	241	100.00

dominant occupations represented were manual labor (29.3 per cent.), housework (22.3 per cent.), and skilled work (15.4 per cent.). The sites of involvement of tuberculosis in cases in which positive histories were obtained are listed in Table II. The duration of symptoms in the entire group of 480 cases is given in Table III. The respective sites of the lesions as determined roentgenographically are shown in Table IV. At the time of operation, deformity was found in 351 cases, or 73.1 per cent.

Abscess formation was present in 250, or 52 per cent., of the 480 cases at the time of operation. Of the remaining 230 cases in which abscess formation was not noted before operation, abscess was discovered subsequently in twenty-two, or 9.6 per cent. Cave reported that he found roentgenographic evidence of abscess formation in 75 per cent. of his cases and clinical evidence of it in 25 per cent. It is our policy to leave the abscesses alone unless they are causing symptoms of pressure or unless there is bone absorption, as is found in the thoracic region. We believe that incision and drainage are rarely indicated and that aspiration, when necessary, should be performed through healthy tissue. Costotransversectomy may be of value in those cases in which thoracic abscesses have caused erosion of bone with irritation of the cord. We do not feel that the presence of an abscess is a contra-indication to operation; on the contrary, we agree with some who believe that it is an indication (Cato, Albee). When the patient's general resistance is good, the abscesses seem to absorb more rapidly following fusion. Sinuses heal best when the patient is treated by immobilization and heliotherapy. When an abscess forms postoperatively, it is not necessarily caused by operation; the abscess usually is present and unrecognized until an increase in size or calcification occurs and is noticed.

Ornstein and Ulmar, in 1935, were amazed at the extensiveness of

TABLE III  
DURATION OF SYMPTOMS

Duration *	Patients	Per Cent.
0 to 5 months.....	37	7.71
6 to 11 months.....	42	8.75
1 to 2 years.....	113	23.54
2 to 3 years.....	86	17.92
3 to 4 years.....	55	11.46
4 to 5 years.....	43	8.96
5 years and more.....	104	21.66
Total.....	480	100.00

\* Mean duration = 2.5 years

tuberculous destruction of vertebral bodies that can exist without symptoms or signs of tuberculosis of the spine and without roentgenographic findings. Whitman found multiple foci of infection in the spine in sixteen cases of a series of 1355 patients, and Peabody reported them in thirteen of a series of 312. Finkelstein and his coworkers stated that in their series of cases, abscesses developed in 20 per cent. of those patients for whom operation was performed and in 18 per cent. of those not treated surgically.

At the time of examination there was evidence of paraplegia or spinal irritation in eighty-four, or 17.5 per cent., of our 480 cases. Butler found that 11.4 per cent. of his 801 patients, seen at four English hospitals, had had the same complications. For those patients who were seen early, treatment was primarily conservative, unless abscess formation caused pressure absorption of bone with symptoms that progressed in spite of conservative care. In such instances, costotransversectomy may be of

TABLE IV  
SITE OF LESION, AS DETERMINED ROENTGENOGRAPHICALLY

Regions Involved	Patients	Per Cent.
Cervical.....	1	0.21
Cervicothoracic.....	2	0.41
Thoracic.....	200	41.67
Thoracolumbar.....	78	16.25
Lumbar.....	199	41.46
Total.....	480	100.00

TABLE V

FIVE-YEAR RESULTS WITH VARIOUS OPERATIONS (396 TRACED PATIENTS OUT OF 480 OPERATED ON)

Condition Five Years after Operation	Total		Operations					
			Albee Massive Graft		Hibbs Fusion		Osteoperi- osteal Graft	
	Pa- tients	Per Cent.	Pa- tients	Per Cent.	Pa- tients	Per Cent.	Pa- tients	Per Cent.
Good, able to work . . . . .	252	63 64	227	64 30	19	57.58	6	60 00
Improved from original con- dition . . . . .	31	7.83	26	7 36	4	12 12	1	10 00
Temporarily improved, re- lapsed . . . . .	15	3 79	13	3 71	1	3 03	1	10 00
Not improved . . . . .	25	6 31	21	5 94	3	9 09	1	10 00
Died within less than 5 years	73	18 43	66	18 69	6	18 18	1	10 00
Total . . . . .	396	100 00	353	100 00	33	100 00	10	100 00

value. Patients with mild symptoms may experience paraplegia, due to the frequency with which the disease is situated in the thoracic spine where respiration causes continuous movement. The majority of all patients will respond to sun treatment and immobilization. The operation to produce fusion of an involved region of the spine, if undertaken at all, should be performed with the utmost care, and the chisel should be used without undue trauma to tissue and bone. Seddon, in 1935, stated his opinion concerning laminectomy; he said that it "is to be condemned; the results are appalling". He, however, believed that it is indicated in some instances. Bennett believed that it is indicated for patients with paraplegia when there is no response to conservative treatment and when the Queckenstedt test is positive. Cave thought that spinal irritation or paraplegia, in the majority of cases, is due to constriction resulting from tuberculous granulation tissue or pressure oedema and rarely to bone deformity, and he favored conservative treatment. We have noted that spinal irritation and paraplegia afflicted principally those patients who had neglected proper care of themselves.

Fracture of a bone graft occurred in sixteen patients within five years of the time of operation; in seven of these, a second operation resulted satisfactorily. Several had had a second operation elsewhere. It was noted that there was an increasing deformity postoperatively in thirteen cases; in fourteen, there was drainage postoperatively with partial loss of the graft in six. Our surgical mortality in this series of 480 patients was less than 1 per cent.

The interpretation of the results of treatment of tuberculosis of the spine—classifying the patients into two groups, those treated surgi-

cally and those treated by conservative methods—is an extremely difficult problem even under the best of circumstances. Possibly one might better say the conservative method and the conservative method plus surgical treatment, for the majority of orthopaedic surgeons have recognized that prolonged rest in recumbency, heliotherapy, and a nutritious diet are the primary basic forms of treatment and that surgical fusion is an aid in strengthening the natural ankylosing process. Many of our patients come from rural districts that are a considerable distance from the Clinic, and the majority of them have received little or no treatment. They are principally adult workers who have had symptoms for some time. In such a group of patients it is difficult to supervise postoperative care, and it is necessary for us to rely on the cooperation of the patient, the relatives, and the local physician. Furthermore, the average duration of symptoms of two and one-half years, during which time there was lack of treatment in 56 per cent., would indicate that the majority of these patients would have experienced considerable destruction of bone with complications such as deformity, abscesses, and irritation of the spinal cord.

Inasmuch as our patients, in many instances, come to the Clinic without having had a diagnosis made and are unable to remain here for hospital care over a period of years because of economic reasons, we must give the best advice and treatment possible in the short time available and then refer them back to their local physicians for further postoperative care. Many times, patients who have had no care prior to their registration at the Clinic come for examination and diagnosis and expect to return home and have treatment there. An estimate of the subsequent care and the results obtained in such cases is difficult to determine unless the patient returns for examination or a report is obtained by correspondence. Of this series of 480 patients, we have been able to trace 396 for a period of five years or more. We have judged the result good when the patient has been able to return to an occupation, although not necessarily to the one which he may have been engaged in prior to operation. It is interesting to note, however, that many patients were able to return to an occupation in which hard labor was required. It will be noted in Table V that 63.64 per cent. of the results have been classified as good, irrespective of the type of operation performed, and the results in those cases in which the patient had massive bone grafts were slightly better. There was improvement over the original condition in 7.83 per cent., no improvement in 6.31 per cent., and death had occurred within less than five years in 18.43 per cent. There was temporary improvement in 3.79 per cent., but this was followed by relapses.

Of the twenty-eight patients, who were less than sixteen years of age and who were operated on during the twenty-three-year period from 1912 to 1934, sixteen had had conservative treatment prior to their registration at the Clinic; one had had a manipulation, one had had a tuberculous lymph node removed, and ten had had no treatment. The site of the lesion was in the cervicothoracic region in one; in the thoracic region, in

thirteen; in the thoracolumbar region, in five; and in the lumbar region, in nine. At operation, massive grafts were applied to the spine in eighteen of these cases; a Hibbs fusion operation was performed in six; a Hibbs operation and massive graft, in two; and osteoperiosteal grafts, in two. The mean duration of the disease was twenty-one months, and in all cases deformity had occurred. One patient died of shock three days post-operatively. In twelve of these twenty-eight cases, the results were good; there was improvement in two, temporary improvement with relapse in one, and no improvement in four; four patients died within five years of date of operation, and we lost track of five. Abscesses were present in all cases preoperatively. These patients came for an opinion and treatment and remained in the hospital, as a rule, for only a few weeks, when they returned home to continue treatment under the care of their physician. No doubt, had they remained in an institution where continuous orthopaedic treatment would have been carried out, the results would have been better than they were. It is fortunate that in recent years children are given the opportunity of hospitalization where prolonged preoperative and postoperative care, as well as conservative care, are given when indicated.

In reviewing the records of this group of surgical cases, we were impressed by the fact that the result often appeared excellent and the patient felt that he had been cured, when some infectious process, such as influenza, caused debility or injury or excessive strain and resulted in a relapse. On the other hand, some were able to carry on the heaviest type of labor, such as farm work and that of a telegraph lineman, without apparent harm.

The results of any analysis of cases in which the patients are treated by surgical fusion will depend on the author's interpretation of the facts and the duration of relief from symptoms, and will vary as to whether the results are tabulated at the end of one, three, five, or more years. Inasmuch as it is a common practice to report the results of treatment at the end of five years, I have done so in this report. Furthermore, the results are variable according to the method used in interpreting just what is a cure. When do we know that a patient who has had tuberculosis is cured? The spine may be fused posteriorly and the disease may appear quiescent, the patient may return to work and consider himself well, the roentgenograms may even appear to show evidence of calcification and absorption of the abscess, fever may have abated, and all pain may have been alleviated, yet living organisms persist in the region that has been affected by the disease. When fusion is produced, the region of involvement in the spine is immobilized, thus effecting something which no other form of fixation, such as that obtained by means of plaster jackets, braces, or recumbency, can bring about. In such cases, respiratory motion and other muscular movements no longer add their trauma to an already diseased tissue. Why, then, is it that we have heard so much about the failure of fusion? We cannot eradicate the disease in the spine as we do in some of

the more exposed articulations such as the knee, and we have no specific medication to produce a cure. These facts leave only the alternative of employing the conservative or the surgical-fusion methods of treatment, or a combination of the two. We believe that in selected cases a combination of the two forms of treatment offers the best result.

In 1919, I reported a series of 100 cases, in which the patients had had surgical fusion of the spine, and I expressed the following opinion: "It has been our experience that the most favorable results are to be obtained by a proper selection of patients to be operated on and the continuance of the conservative treatment after operation until, in the judgment of the surgeon, the disease process has been arrested. The bone graft used in our cases was curved to fit the deformity. The very young and those adult patients who present formidable complications are treated conservatively. . . . Patients under five and adults who present complications, such as sinuses and pulmonary tuberculosis, should be treated by means of the Bradford frame . . . until the disease has been arrested. . . . In some instances when the general condition has improved, but the symptoms of spinal disease remain unarrested after such treatment, bone graft operation may be resorted to with benefit and the braces afterward removed. . . . The Rollier sunshine treatment should be urged, and it should be instituted while the patient is under control. All patients treated by recumbency should be kept in an institution long enough to instruct the parents or other relatives with the method." When such a regimen is carefully followed, the combined methods of treatment should result in added benefit to the patient. Some patients are doomed in spite of having had the benefit of the best institutional care, and this, in many instances, is due to the lateness of diagnosis and the presence of advanced tuberculosis in other organs at the time of consultation.

Again, I wish to emphasize the difference between the practice of the orthopaedic surgeon who cares for institutional cases and deals principally with children and the more diverse practice of the orthopaedic surgeon who deals with adults. In my experience, many of these adults have been unable to obtain an early diagnosis and they continue to work until evidence of kyphosis or spasticity is apparent. When confronted with the necessary prolonged treatment in recumbency, such patients are anxious to grasp at any method which might promise relief of symptoms in a shorter period of time. The fusion operation has afforded structural support when properly applied and should be given the credit of being an important aid in treatment in some cases, and more especially for selected adult patients in whom the disease is not too advanced and whose general condition is satisfactory. I admit my failure to apply the word "cure" in this report; like many, I have found that some patients with the so-called cures have sometimes had relapses in spite of the type of treatment. On the other hand, by using the five-year basis for the report and by employing the classification illustrated in Table V, I think that I have conveyed some idea of what actually has happened.



## SUMMARY

Operation to produce surgical fusion of the spine is a comparatively safe procedure. It may be performed without danger of aggravating the disease process. It aids in giving stability to the diseased portion of the spine. It does not necessarily prevent extension of the disease, formation of abscess, irritation of the spinal cord, or paraplegia among patients whose resistance is not good. It is best to delay spine fusion for children who are sick; then, when the process becomes quiescent, spine fusion can be employed as an internal splint to aid in ankylosis. The results of spine fusion as a treatment for tuberculosis of the spine are probably better in adults than in children. An operation that produces fusion of the entire region of involvement gives better immobilization and, consequently, better results than does one that effects fusion of a more limited region. It is often impossible, in the early stages of tuberculosis of the spine, to determine the exact extent of the process either by clinical or by roentgenographic examination.

At the end of five years, 396 of our 480 patients had been traced; of these 396 patients, 63.64 per cent. had returned to an occupation, 7.83 per cent. had obtained improvement, 3.79 per cent. had had temporary improvement with relapse later, 6.31 per cent. had had no improvement, and 18.43 per cent. had died.

The best results are obtained when patients are carefully selected for operation, when spine fusion is employed during the period of healing of the disease, and when such treatment is reinforced by conservative treatment for a prolonged period of time.

The paramount requirement for every patient who has tuberculosis of the spine is rest, heliotherapy, and a nutritious diet. No surgical treatment can offset the value of conservative treatment.

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## TUBERCULOSIS OF THE SPINE

END-RESULT SERIES STUDIED AT CHILDREN'S MEMORIAL HOSPITAL,  
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In the presentation of end-result studies of any pathological condition, the investigator is bewildered frequently by the multitudinous phases of the disease process and the unending variety of channels of thought which are opened at every turn. He must of necessity restrict his efforts to an impartial interpretation of facts as they have been recorded over a considerable period of time. These facts or observations are registered by many different individuals with varying points of view and often with diverse interests. The medical man naturally sees the progress of disease from a different perspective than does the orthopaedic surgeon. His observations often complement those of the surgeon and because of this give a more complete portrayal of the events. These varied observations should be incorporated in the presentation of any review made to evaluate any plan of therapy. The inadequacy of even the best of records is glaring. The failure of well-planned, long-time supervision and the inevitable loss of follow-up in a certain number of cases is known to all. The findings presented under the term of "end results" are not necessarily facts but the interpretations and conclusions of the observer, and as such are far from infallible. The general conclusions drawn from varied presentations, as in this symposium, will become our guideposts in future efforts in this field of spine surgery.

The cases analyzed in this paper were seen at the Children's Memorial Hospital in Chicago during the years 1930 to 1934, inclusive, and have been observed to the present time,—a follow-up of from five to ten years. This Institution is a general children's hospital with an average occupancy of about 170 patients and a large Out-Patient Department. Few patients have access to institutions especially designed to provide adequate convalescent care. Patients are given care through their twelfth year and are then transferred to other clinics. This is a most unfortunate arrangement for the continuation of proper surgical supervision and is a barrier to prolonged "follow-up" study. The pressure of patient volume, age limits, etc., have their influence on methods of treatment and should be kept in mind.

Our conception of tuberculous spondylitis may be summarized as follows:

1. It is a secondary pathological lesion,—an infectious lesion of the spine in a patient who otherwise is tuberculous.
2. The course of development of the spinal lesion parallels that of

tuberculous lesions elsewhere in the body, except for the rigid character of the host tissue and the unique mechanics of the spine.

3. Healing results from the summation of the following factors:

- a. The inherent immunity of tissue to this infection;
- b. The reaction of cellular elements adjacent to the lesion, round-cell infiltration, fibrosis, etc.;
- c. The physicochemical processes contributing to calcification.

4. The favorable outcome of such a lesion should not be referred to as healing in the sense that this term suggests complete obliteration of the infecting organism.

We have attempted to keep these factors in mind throughout our treatment of tuberculosis of the spine and have consulted frequently with physicians specializing in pulmonary disease as well as with thoracic surgeons, who have a surgical approach to their problem not dissimilar to that of the orthopaedic surgeon. The object of both of these special surgical approaches is: first, to facilitate natural healing processes by the obliteration of the area of pathology by fibrosis and calcification; and, second, to preserve physiological functions to the greatest possible degree. The question of deformity resulting from the tuberculous lesion is the point at which the thoracic surgeon and the spine surgeon diverge from otherwise parallel courses. The thoracic surgeon invites deformity of that portion of the lung by employing every possible means at hand to permit collapse and consolidation of the pathological area. To this end, pneumothorax, section of the phrenic nerve, thoracoplasty, etc., are widely employed. The compensatory expansion of the adjacent lung minimizes the deformity produced.

In contrast to this course, the orthopaedic surgeon devotes his major efforts to the prevention of deformity by a great variety of manipulative and operative procedures and apparatus. We should consider the possibility of our having underestimated the significance of deformity in the ultimate healing of the tuberculous spinal lesion. In our efforts to prevent deformity and the resultant collapse of the diseased area, is it not possible that we have actually interfered with basic healing and have delayed or prevented recovery? It is true, however, that bone will regenerate to some degree, especially if subjected to physiological strain.

In our cases we have tried to reach a mean between the extremes of therapy suggested. We desire a measure of collapse with the resulting deformity to facilitate obliteration of the disease area, at the same time hoping to keep it minimal in degree. We also hope to prevent the occurrence of gross deformities: first, by early diagnosis; second, by the institution of the most positive therapeutic measures at our command; and third, by the early resumption of normal activity to permit natural compensatory changes of normal tissues.

We agree with all the accepted nutritional hygienic and supportive measures and, with some reservations, with the principle of rest. We seek

the amount of rest compatible with normal physiological functioning of the patient as a whole. Absolute rest is accompanied by atrophy even of normal structures and necessarily by impairment of their normal physiology. Frequent postural changes and active use of the extremities are encouraged. Every effort to splint the area of disease itself is carried out. This can be done best by surgical fusion of the involved area of the spine, providing the operation is not shock-producing or devitalizing to the patient.

All patients whose cases are diagnosed as tuberculosis of the spine in our Clinic are admitted to the Hospital at once and are subjected to thorough examination by a member of the medical staff. The lungs, kidneys, and tonsils are examined for possible tuberculous foci. Adjuvant medical and nutritional measures are instituted, and the patient is

TABLE I  
SEX AND RACE INCIDENCE IN CASES TREATED BY SPINE FUSION

Sex	Cases	Per Cent.
Male	16	41 03
Female	23	58 97
Total	39	100 00
Race	Cases	Per Cent
White	35	89 74
Negro	4	10 26
Total	39	100 00

given bed rest, supported only by a fracture board, which replaces the usual bed spring. These measures are continued for several weeks until the general condition of the patient either is definitely on the upgrade or fails to show a favorable reaction to this regimen. The patient is then subjected to a rapid, gentle spine fusion of the diseased area, preceded by thorough preparation and followed by supporting postoperative measures. At operation, particular care is used to avoid unnecessary pressure or trauma. Bone chips are removed without a mallet. Hemostasis is secured by gentle packing. The patients are operated upon in the forenoon and, as a rule, are taking their regular diet by evening. Supportive measures are continued as long as necessary, usually from twenty-four to forty-eight hours. They are then returned to regular ward care with no restrictions other than the maintenance of a horizontal position on a fracture-board bed. Calcium in the form of dicalcium phosphate, cod-liver oil, hydrochloric acid, milk, and iron are given in addition to a generous nutritive diet. Occasionally a blood transfusion is employed. After a period varying from three to eight months, a gradual resumption

TABLE II  
DURATION OF DISEASE \* BEFORE FUSION OPERATION

Period (Years)	Cases	Per Cent.
1 or less . . . . .	16	41.03
1 to 2 . . . . .	8	20.51
2 to 3 . . . . .	3	7.69
3 to 4 . . . . .	4	10.26
4 to 5 . . . . .	2	5.13
5 to 6 . . . . .	3	7.69
6 to 7 . . . . .	2	5.13
7 to 8 . . . . .	1	2.56
Total . . . . .	39	100.00

\* Estimated.

of the upright position is permitted. The back is supported by a spine brace. These periods of activity are lengthened as tolerated. In most instances, the patients are returned to their homes with instructions regarding rest periods, cod-liver oil, calcium, etc. They are then followed at frequent intervals in the Out-Patient Department.

Thirty-nine consecutive cases, treated at the Children's Memorial Hospital during the years 1930 to 1934, inclusive, were selected for study. The end results at the termination of from five to ten years are herein reported. These were studied and compared with those in thirty-six conservatively treated cases observed at the same Hospital during the previous five-year period. Because of the transfer of these latter cases to several other clinics, final end-result studies were impossible.

Of the thirty-nine cases in the 1930-1934 group, 41.03 per cent. were males and 58.97 per cent. were females; 89.74 per cent. were white and 10.26 per cent. were negroes (Table I). The majority were of central or southern European stock, corresponding to the nationalities served by this Hospital. All came from families whose monthly incomes were less than \$125.00. The approximate age at onset varied from one to ten years, with an average of three years. Special efforts were made to establish possible contacts with known tuberculous cases at home. In twenty-five,

TABLE III  
COMPLICATIONS ON ADMISSION

Complications	Cases	Per Cent.
Spinal abscess . . . . .	27	69.23
Primary pulmonary tuberculosis . . .	24	61.54
Active pulmonary tuberculosis . . .	5	12.82
Keratitis . . . . .	2	5.13
Paraplegia . . . . .	3	7.69

no known contact could be established. In fourteen, or 36 per cent., of the cases, positive histories of contact with one or more members of the household having active pulmonary disease were found. In ten cases deformity was the presenting symptom. Other patients complained of painful walking, pain in the hips, back pain, abdominal pain, restless nights, and night cries in varying degrees of severity. Many of these patients had been seen by physicians previously without recognition of the pathology of the spine.

An estimate of the duration of the disease of the spine (Table II) was based on the duration of symptoms and the deformity present, as revealed on questioning the parents.

On admission, thirty-seven patients showed positive tuberculin reactions to human-type tuberculin either by the von Pirquet or by the Mantoux test. One patient showed a negative reaction to human-type tuberculin, but a positive reaction to bovine tuberculin. No record was made in one case.

Roentgenograms of the chest were taken on admission in all cases. Twenty-four patients, or 61.54 per cent., presented healed primary pulmonary lesions; five, or 12.82 per cent., showed active pulmonary lesions. The films in the remaining ten were interpreted as negative for pulmonary pathology. Two patients had keratitis, and three had paraplegia. (See Table III.)

Roentgenograms on admission showed that two vertebrae were involved in twenty-three cases; three, in eight cases; four, in three cases; five, in four cases; and nine, in one case. In all, 111 vertebrae were involved, as follows:

<i>Vertebrae</i>	<i>Cases</i>
Thoracic:	
I.....	2
II.....	2
III.....	3
IV.....	3
V.....	3
VI.....	5
VII.....	10
VIII.....	10
IX.....	11
X.....	13
XI.....	14
XII.....	8
Lumbar:	
I.....	6
II.....	4
III.....	7
IV.....	6
V.....	3
Sacral:	
I.....	1
Total.....	111

TABLE IV  
AGE AT OPERATION

Age (Years)	Cases	Per Cent.
1 to 2.....	1	2.56
2 to 3.....	2	5.13
3 to 4.....	6	15.38
4 to 5.....	7	17.95
5 to 6.....	5	12.82
6 to 7.....	2	5.13
7 to 8.....	4	10.26
8 to 9.....	2	5.13
9 to 10.....	3	7.69
10 to 11.....	5	12.82
11 to 12.....	2	5.13
Total.....	39	100.00

Roentgenograms of the spine revealed abscesses in twenty-seven cases, or 69 per cent. These were graded on a 1 to 4 basis according to size, as follows:

Grade	Cases
1.....	6
2.....	11
3.....	8
4.....	2

At the present time the abscesses have disappeared in ten cases, have calcified in nine cases, have diminished in size in three cases, and have

TABLE V  
PERIOD BETWEEN OPERATION AND WALKING WITH BRACE

Period (Months)	Cases	Per Cent.
2.....	1	2.56
3.....	6	15.39
4.....	5	12.82
5.....	10	25.64
6.....	4	10.26
7.....	3	7.69
8.....	2	5.13
11.....	1	2.56
13.....	1	2.56
Total.....	33 *	84.61

\* In 4 cases, 10.26 per cent., there was no record, and in 2 cases, 5.13 per cent., the patients died before walking was permitted. One patient with paraplegia, able to be up in a wheel chair, is included in the 33 cases.



TABLE VI  
END RESULTS

Result	Cases	Per Cent.
Good:		
5 to 9-year follow-up.....	25	64.10
3-year follow-up *.....	4	10.26
Poor:		
Continued activity of the disease.	3	7.69
Paraplegia.....	1	2.56
Death.....	6	15.39
Total.....	39	100.00

\* At the end of this period, these patients were lost track of.

remained the same in roentgenographic appearance in five cases. The size of the abscess had no direct relation to the number of vertebrae involved. In no case did an abscess develop during the course of observation. The smaller abscesses disappeared, while the larger ones calcified or remained unchanged in their roentgenographic appearance. The angulation of the spine at the time of admission was measured in thirty-eight cases. In six cases the angle was between 70 and 110 degrees; in six, between 110 and 140 degrees; in fourteen, between 140 and 160 degrees; and in twelve, between 160 and 180 degrees. The latter group revealed a loss of lordosis in the lumbar spine. In nineteen cases there was an increase of less than 10 degrees over the follow-up period of five to ten years, while in ten there was no increase in the initial deformity. The others showed an increase of from 10 degrees to as much as 35 degrees in one case. These measurements were taken from the normal surfaces of the involved vertebrae and do not reflect the compensatory curves developing in the adjacent normal bone. Patients with an angle of as much as 140 degrees showed little or no external kyphosis.

Paraplegia was present in three cases at the time of admission, but no further paraplegia has developed since. Of these three patients, two have

TABLE VII  
ANALYSIS OF DEATHS

Case No.	Cause of Death	Postoperative Period
1.....	Pulmonary hemorrhage	5 years
10.....	Cardiac amyloidosis	4 years
17.....	Tuberculous meningitis	4 months
32.....	Tuberculous meningitis	20 months
35.....	Tuberculous meningitis	12 months
39.....	Tuberculous amyloidosis	7 months

died, and the third is showing some return of motor function nine years after combined fusion and laminectomy and later costotransversectomy.

The Hibbs technique was used in all cases. One, two, and, in some cases, three normal vertebrae were included at either end of the fused area. Secondary operations were performed in four cases. Sections of rib or tibial grafts, supplemented by bone chips at the site of pseudarthrosis, were used at operation. One patient was operated upon three times. Ether anaesthesia was used in all cases with no evidence of increased pulmonary activity. No lower age limit has been established, for sufficient ossification of the laminae has been found to afford good chip grafts in even the youngest patients. Use of tibial grafts has been avoided as unnecessary for fusion, because of the additional trauma involved and because of the latent stimulation of growth of the tibia, resulting in unequal leg length.

In conformity with our conception of early activity, patients were permitted to walk relatively soon. The maximum period of horizontal rest was three months, with the exception of the one surviving patient with paraplegia (Table V).

In following the course of disease, the weight gain was found to be the best index of progress. The weights of the first twenty-two patients were charted, and an accelerated gain was noted in most instances.

Good results were obtained in twenty-five cases (64.10 per cent.). In four cases (10.26 per cent.), in which the patients were followed for three years and then lost track of, the results were good at the end of the observation period. In three cases (7.69 per cent.), there was continued activity of the disease, and in one case of paraplegia (2.56 per cent.), there was some return of motor function. There were no deaths due to operation. (See Table VI.)

Six deaths (15.39 per cent.) occurred in the total series of thirty-nine cases (Table VII). All were caused by tuberculous lesions at periods of from four months to five years following operation.

In considering the outcome of the disease process at this period in the follow-up of these cases, definite criteria are of necessity lacking. The child as a whole must be considered, rather than any one single manifestation of tissue change at the site of the pathological process. The return to normal growth, normal rate of weight increase, and the resumption of normal physiological functions, combined with the subsidence of symptoms and evidences of favorable tissue reaction at the site of disease, should all be considered in the estimate of the stage of the healing process.

If the theory of destruction of the intervertebral disc in spinal tuberculosis is accepted, we hope for complete bony fusion at the level of disease. If the theory of the survival of the disc is adhered to, we can accept evidence of new-bone formation as a criterion of healing. We feel that the fate of the disc varies in different cases,—it is destroyed and absorbed in some and it survives in others. The change in angulation of the kyphos

reflects collapse of weakened bone structures as well as altered bone growth resulting from epiphyseal destruction.

The importance of the operation in these cases must be accepted with a proper perspective. At best, it is only a minor incident. In this small series we believe that it has been helpful.

The disappearance of abscesses or their calcification are most favorable signs. If the patient shows a normal return to a tolerance of all normal activities and the disappearance of symptoms, the result may be considered good. We do not use the term "cured" in any instance. This means that the follow-up of a case of tuberculosis of the spine should be life long.

# TUBERCULOSIS OF THE SPINE IN CHILDREN

## A REVIEW OF SIXTY-THREE CASES FROM THE LAKEVILLE STATE SANATORIUM

BY Z. B. ADAMS, M.D., \* BOSTON, MASSACHUSETTS

This is an analysis of sixty-three cases of tuberculosis of the spine treated at the Lakeville State Sanatorium. All of the patients were under twelve years of age at the time of admission to the Sanatorium, and all have been discharged for at least five years. Twenty-five of these patients have died, either while at the Sanatorium or since discharge, and thirty-eight have recovered. Thus the percentage of deaths is 40 and that of recoveries is 60.

### STATISTICAL ANALYSIS

#### *Patients Who Died*

Of the twenty-five patients who died, sixteen reacted to both human and bovine tubercle bacilli; seven, to the human type alone; and two to the bovine type alone.

The regions of the spine which were involved were as follows: cervical, one case; high thoracic, two cases; low thoracic, ten cases; and lumbar, twelve cases.

Among these twenty-five cases, there were the following complicating conditions: paraplegia, six cases; tuberculosis of the hip, three cases; tuberculosis of the knee, one case; tuberculosis of the ankle, one case; tuberculosis of the kidney, one case; and tuberculous ophthalmia, one case.

Roentgenographic examination showed the presence of abscesses in seventeen cases and no abscesses in eight cases.

The Hibbs fusion operation was performed in two cases; the Albee bone-graft operation was done in four cases; laminectomy was carried out in three cases; and in one case the nature of the operation is not known.

#### *Patients Who Are Living*

Of the thirty-eight patients who are still living, there was a positive skin reaction to both human and bovine tubercle bacilli in twenty-six; to the human type alone, in seven; and to the bovine type alone, in five.

The involvement of the spinal regions was as follows: cervical, one case; high thoracic, nine cases; low thoracic, thirteen cases; lumbar, fourteen cases; and sacral, one case.

The complicating conditions in this group consisted of: pulmonary disease, five cases; paraplegia, two cases; cervical glands, two cases; tuberculosis of the hip, two cases; sacro-iliac tuberculosis, one case; tuberculosis of the ankle, one case; tuberculous mastoiditis, one case; tuberculous otitis media, one case; and phlyctenular keratitis, one case.

\*Deceased.

Roentgenographic examination revealed the presence of abscesses in twenty-four cases and no abscesses in fourteen.

In fourteen of these cases the Albee bone graft was employed; in six, the Hibbs fusion operation was performed; in five, osteoperiosteal grafts were used; and in the remaining thirteen cases, no operation for locking the spine was carried out. Four patients had had sinuses that had discharged and healed.

#### GENERAL CONCLUSIONS

The study of this disease shows that the micro-organisms of tuberculosis can reach the spine only through the blood stream. The original site of entry is difficult to determine at the stage of the disease when a spinal lesion makes itself known. Later the appearance of calcified glands in some part of the body may be a clue to the original place of entry. The caries of the spine is a local nidus of a general disease. When the lesions in the spine are multiple—sometimes two, three, or four distinct foci, separated by normal areas—or accompanied by tuberculous lesions in the hip, knee, ankle, or some other site, in my opinion the mortality is due not to the lesion or the extent of the lesion, but to one of two factors: (1) the low resistance of the individual, or (2) a highly virulent strain of the tubercle bacillus. The use of sulfanilamide in these cases is not warranted. It clears up the intercurrent infection, if there is a mixed infection, but it does not attack the tuberculous organism because of its waxy capsule.

The healing of the spine does not prevent the development of complications, of other foci in the spine, or of foci in other joints or in the kidney or lungs. Efforts to heal these patients should include the building up of the general condition and the healing or removal of the local foci.

It is my belief that if a kyphos has developed, due to the collapse of the vertebral bodies, it is not wise to correct the deformity by forcing the collapsed vertebrae apart. Prevention of the collapse is warranted and should be attempted, but an empty space in the anterior column should not be produced. Healing by solid bony fusion in the diseased area requires time,—a much longer period than is usually allowed. The roentgenograms of the spine do not always show the full extent of the disease, for infiltrated bodies may be present without any narrowing of the discs or other roentgenographic evidence. Careful and thorough fusion of the laminae produces an internal splint and is an aid in the healing of the disease. These fused areas will bend, and no weight should be put on the bodies in the center of the kyphos until the healing is well advanced.

We never operate on debilitated patients; we wait until the general condition has improved. In tuberculosis of the lumbar spine in children, where the process apparently has started in the disc and has invaded the bottom of the vertebra above and the top of the vertebra below, solid bony fusion will result in a comparatively short time—two or three years—without any operative interference.

# END RESULTS OF TREATMENT OF POTT'S DISEASE

BY R. I. HARRIS, M.B., F.R.C.S. (C), AND H. S. COULTHARD, M.B.,  
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A brief statement regarding the work which is being done on Pott's disease at Weston Sanatorium is necessary in order that the subsequent data may be interpreted clearly.

Weston is a suburb of the city of Toronto. The Sanatorium has been in existence for thirty-six years but only during the past nine years has it provided facilities for the treatment of surgical tuberculosis. The surgical unit is closely associated with the Department of Surgery of the University of Toronto. Adequate facilities are provided for the treatment of all phases of tuberculosis by surgical measures. To this institution come patients of all ages with bone and joint tuberculosis, from all parts of Ontario.

Available for this review are eighty-five cases of Pott's disease in which treatment was commenced not later than January 1935. We have lost contact with five of these patients; four of them have been deported as undesirable aliens, and one we have been unable to find. The remaining eighty cases have all been reviewed within recent months and the data so obtained is the basis of this report. (See Table I.)

## BASIC PLAN FOR TREATMENT OF POTT'S DISEASE AT WESTON

Our approach to the problem of the treatment of Pott's disease has been guided by a basic plan, the outline of which must be given in order

TABLE I  
ANALYSIS OF CASES FROM WESTON SANATORIUM BY AGE GROUPS  
TREATED IN OR BEFORE JANUARY 1935 \*

Age (Years)	No. of Cases	Totals	Per Cent
2 to 5	7	13	16 25
6 to 10	2		
11 to 15	4		
16 to 20	6	58	72 50
21 to 30	36		
31 to 40	16		
41 to 50	2	9	11 25
51 to 60	4		
61 to 66	3		

\* Total cases treated and discharged, 85; total followed and forming the basis of this analysis, 80.

that our figures may be interpreted properly. It is our belief that all cases of Pott's disease are best treated by a combination of conservative and surgical measures unless the patient's condition renders him unfit for surgery. Our contribution to this symposium, therefore, is concerned chiefly with patients upon whom spine fusion has been performed as an important part of their treatment. It is true that a certain number of our cases have been treated by conservative measures only, and the results are reported here also. The results in these instances are scarcely a fair picture of what might have been obtained under different circumstances, since nearly all of these patients were so treated because, due to extensive disease elsewhere, secondary infection, or other complications, they were poor surgical risks. They were the poorest risks among our patients. This explains to a considerable degree the less favorable results.

On the other hand, the results which we have obtained by rest and spine fusion represent a fair example of what can be accomplished by this method of treatment. Unless there were important contra-indications, every case of Pott's disease was so treated. Our adherence to this plan of treatment is based upon the belief that rest is the most important agent in the cure of tuberculosis. In the last analysis, the patient cures himself by his own mechanism of defense. His powers of resistance against the infection can be greatly enhanced by certain measures proved valuable by years of clinical experience. Of these, rest is by far the most important. The more complete and the more prolonged the rest, the greater the certainty of cure. Spine fusion is of value because, properly performed, it maintains rest in the diseased segment of the spine more efficiently than does any other method, and does so for the remainder of the patient's life. It is our opinion that rest obtained by spine fusion ensures cure of Pott's disease (1) more rapidly, (2) with greater certainty, and (3) with less likelihood of recurrence, than any other form of treatment.

Our basic plan, therefore, has been to treat the patient by recumbency and fixation for a length of time sufficient to enable him to obtain mastery of the infection. We have found a Whitman frame the most convenient apparatus on which to carry out this regimen. During this period of recumbency the spine is fused. Fusion is not undertaken until the patient shows signs of mastering the infection, and at least six months must elapse after fusion before we think it safe to allow him to get up. Favorable cases are recumbent for a year, during the middle of which period a spine fusion is performed. Three months' ambulatory treatment follows so that the minimum period of hospital treatment in favorable cases is about fifteen months.

A variety of circumstances may necessitate lengthening the period of recumbency. The presence of persistent psoas abscess or lumbar abscess, discharging sinuses which interfere with the field of operation, foci of tuberculosis elsewhere in the body, and failure to display quickly

TABLE II

CLASSIFICATION OF CASES ACCORDING TO METHOD AND LENGTH OF TREATMENT

Length of Treatment	Method			
	Recumbency and Bone Graft		Recumbency only	
	Cases	Per Cent.	Cases	Per Cent.
Within 15 months.....	12	24.00	1	3.33
15 to 24 months.....	18	36.00	4	13.33
2 to 3 years.....	10	20.00		
3 to 4 years.....	5	10.00	5	16.67
After 4 years.....	4	8.00	7	23.33
Death occurred before cure.....	1	2.00	13	43.34
Total.....	50	100.00	30	100.00

evidences of mastering the infection all necessitate longer treatment. Table II indicates the length of time our eighty cases were under treatment.

## TYPE OF SPINE FUSION

Although the spine fusion we have been performing has undergone certain modifications during the years, it has always been essentially the same,—a fusion obtained by using large and relatively heavy bone grafts. For this purpose, two grafts are taken from the shin. They are turned on edge and their cancellous surfaces placed against the denuded spinous processes of the involved vertebrae and those of one normal vertebra above and one below. Cancellous bone and chips, also taken from the tibia, are packed into the interstices of the field of operation. The two large grafts are fastened in place by stainless-steel wire sutures through the upper and lower ends. We feel this operation has the advantages of simplicity and rapidity while ensuring rigid fixation of the involved segment of the spine.

## FORMS OF TREATMENT ACCESSORY TO SURGERY

Although the basis of our treatment is rest, obtained by prolonged recumbency and supplemented by spinal bone graft, certain accessory forms of treatment are utilized and are of value.

*Heliotherapy* is a valuable adjunct in most cases. Certain patients with active pulmonary disease respond unfavorably, but, apart from these, heliotherapy is used with benefit in all our cases whenever the climatic circumstances permit. We can count on six months during which heliotherapy can be administered, but only during three of those months can it be intensive. In spite of these limitations we regard it as a most important addition to treatment.





FIG. 1

Healing by bony ankylosis. Solid bony fusion of the involved vertebral bodies with solid fusion of the graft.

*Abscesses* are treated by repeated aspiration wherever possible. Usually this is sufficient to dispose of the abscess, although occasionally it continues to increase in size in spite of aspiration. In such cases Listerian drainage is utilized (drainage through a small wound into a continuously antiseptic dressing—Keith's solution).

*Secondarily infected sinuses* are difficult to treat and only occasionally are they cured. We have had some success by irrigating the sinuses with Dakin's solution, and one case (in which the secondary organism was hemolytic streptococcus) was cured by sulfanilamide.

#### CRITERIA OF HEALING

In any analysis of the results of treatment of Pott's disease it is necessary to have a clear idea of what is meant by cure. This is difficult to establish, especially in an infection so persistent as tuberculosis.

There are two criteria by which we may form a reasonable estimate of cure: (1) x-ray, and (2) clinical signs. Both must be taken into consideration and sufficient time must elapse to demonstrate that the

cure is real and not apparent. We have adopted the following standards.

### *Healing by Bony Ankylosis*

In this group the remnants of the involved vertebral bodies have fallen together and have fused into a solid pyramidal mass of bone which represents what is left of two or more carious bodies. The bone graft is solidly fused to the spines of the involved vertebrae and to at least one normal vertebra above and one below. The patient presents clinical evidence of cure, normal temperature, no pain, ability to undertake reasonably heavy activity, disappearance of abscesses and closing of sinuses, and adequate weight. This group one can say with great certainty is cured. (See Figure 1.)

### *Healing by Firm Fibrous Ankylosis*

In this group the involved vertebral bodies (usually only two) do not fuse by bone. They are separated by a narrow space occupied by the remnant of the intervertebral disc. The space is small and the spinal bone graft is solid and of adequate extent. The clinical evidence of cure is as

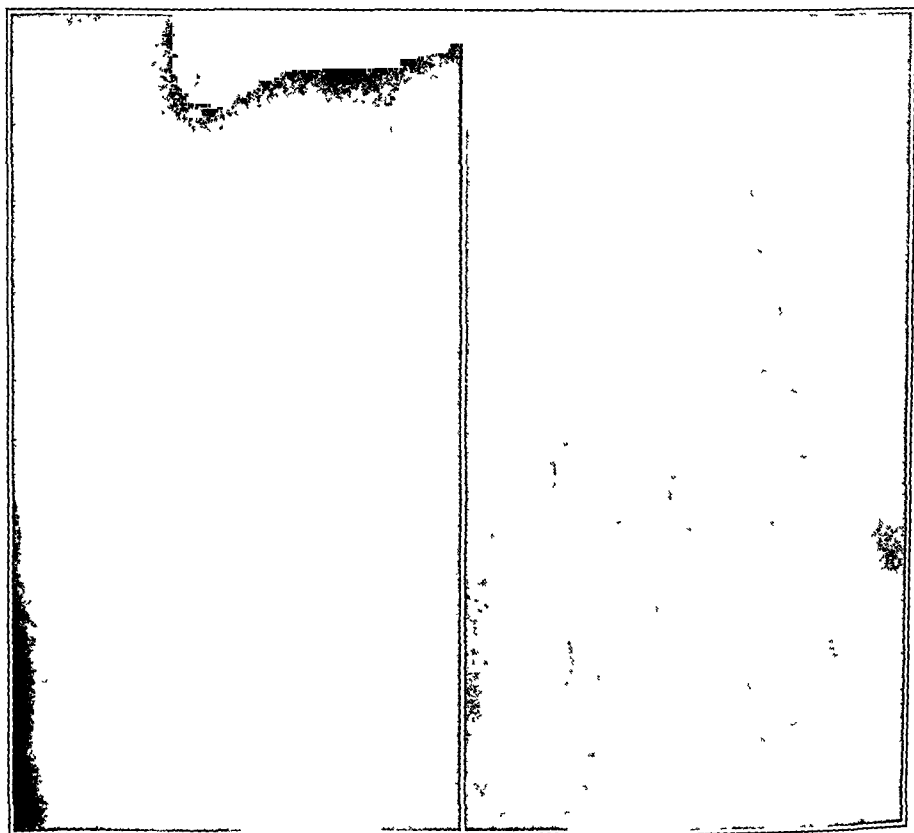


FIG. 2

Healing by firm fibrous ankylosis. The vertebral bodies have settled down upon one another but have not healed by bony union because of the interposition of the remnants of the intervertebral disc. The graft is solid.

TABLE III  
ANALYSIS OF THE RESULTS OF TREATMENT

Result	Method				Total	
	Recumbency and Bone Graft		Recumbency only			
	Cases	Per Cent.	Cases	Per Cent.	Cases	Per Cent.
Bony ankylosis . . . . .	33	66.00	7	23.33	40	50.00
Firm fibrous ankylosis . . . . .	10	20.00	1	3.33	11	13.75
No ankylosis . . . . .	4	8.00	3	10.00	7	8.75
Progressive disease . . . . .	3	6.00	19	63.34	22	27.50
Total . . . . .	50	100.00	30	100.00	80	100.00

already stated. Probably these cases represent just as perfect cures as do the previous group, although the roentgenogram lacks the definite evidence found in the group with bony ankylosis. (See Figure 2.)

#### *Healing without Ankylosis—Unstable Spine*

In this group the vertebral bodies are separated by a considerable space due to (1) too much hyperextension at the site of disease, (2) calcific debris from an abscess, or (3) a sequestrum. The bone graft is fused to an adequate number of spinous processes but it may fracture at the level of the disease because the involved bodies are not stable and great strain comes upon the graft. The clinical evidences of cure may be present or there may be pain on effort. If the graft fractures, exacerbation of the disease may result. (See Figures 3-A, 3-B, and 3-C.)

#### *Failure to Heal or Extension of the Disease*

The outstanding feature of the group is progressive caries in the grafted area or extension of the caries into vertebral bodies beyond the bone-grafted area. The clinical evidences of active disease, including abscess, are present. (See Figures 4-A, 4-B, and 4-C.)

The first two groups can be regarded as *satisfactory* cures. The third

TABLE IV  
COMPLICATIONS ARISING DURING TREATMENT

Complication	No. of Cases	Per Cent.
Abscess . . . . .	72	90.00
Amyloid disease . . . . .	11	13.75
Renal or genital tuberculosis . . . . .	21	26.25
Addison's disease . . . . .	3	3.75
Paraplegia . . . . .	13	16.25
Pulmonary tuberculosis . . . . .	24	30.00

group shows an imperfect but by no means an entirely unsatisfactory result and is classified as *fair*. The fourth group is listed as *failure*. Table III indicates the results of our cases according to this classification.

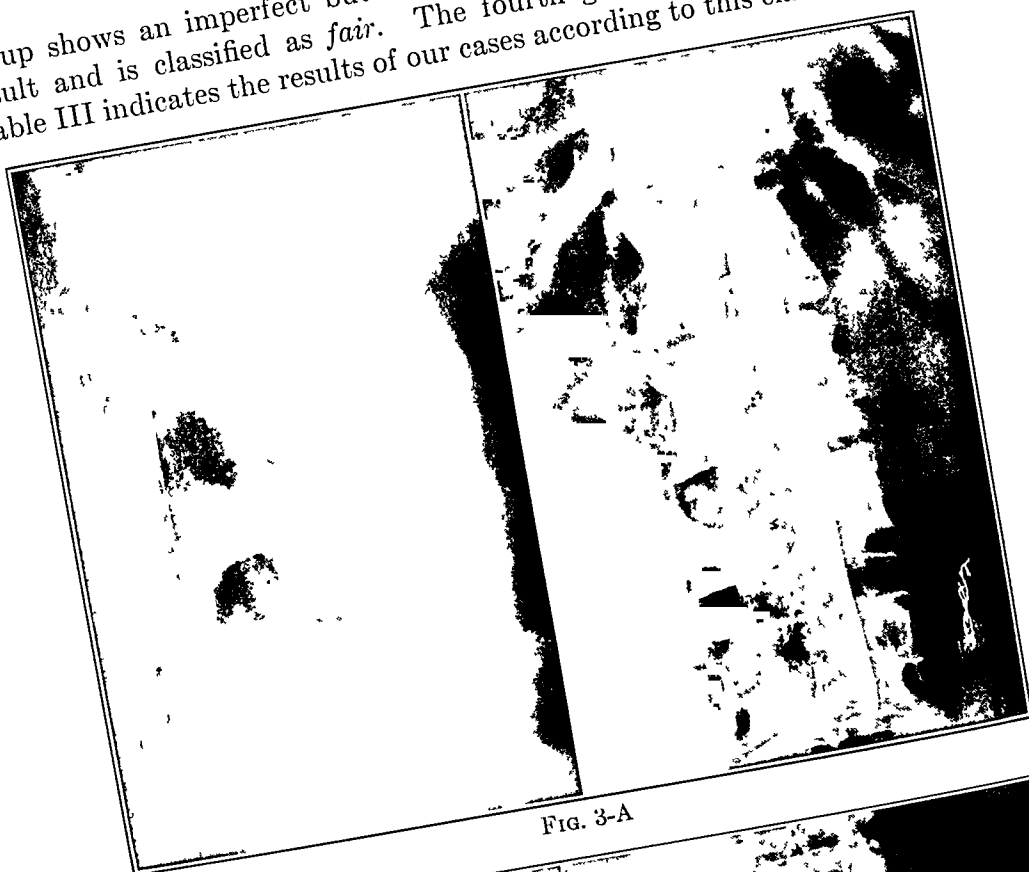


FIG. 3-A

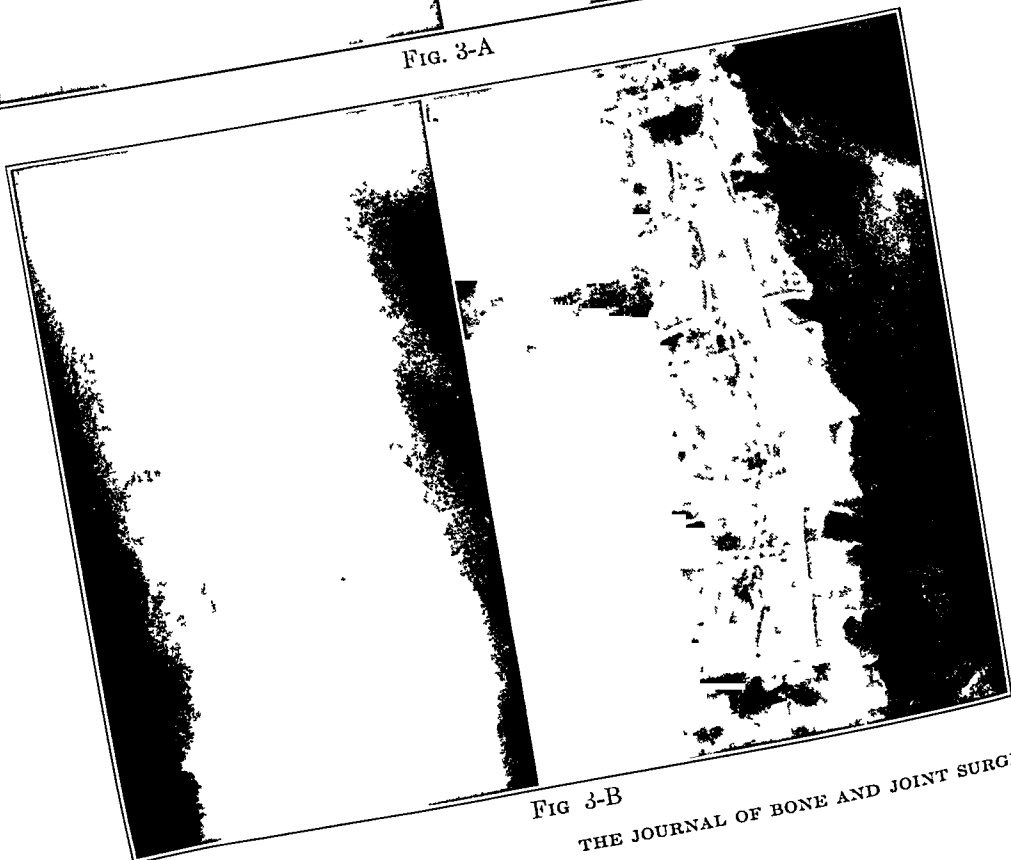


FIG 3-B

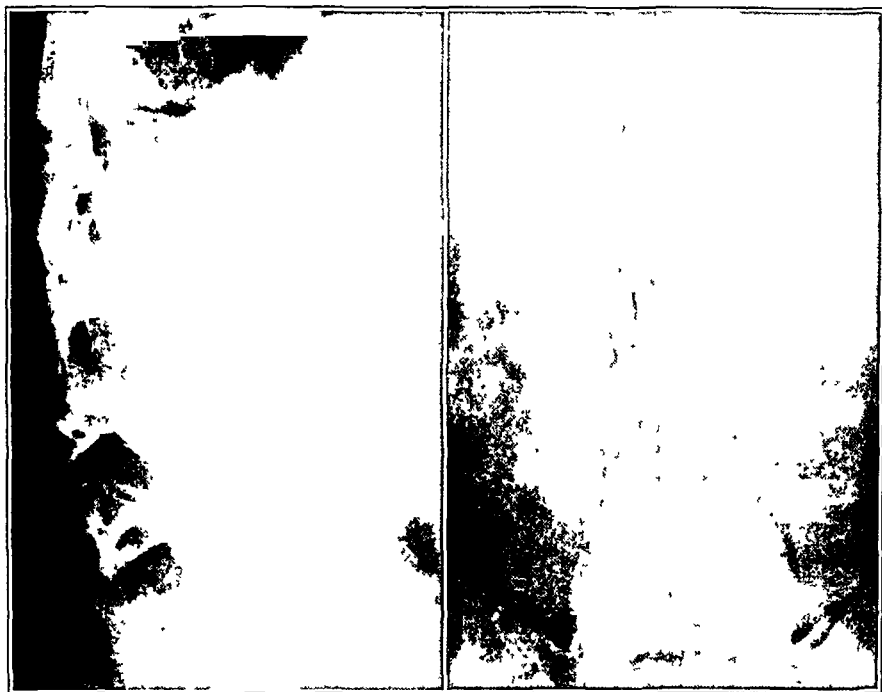


FIG. 3-C

Fig. 3-A: Healing without ankylosis of the vertebral bodies. Unstable spine. In this example, although the bone graft is solidly fused to the spinous processes the vertebral bodies are separated by hyperextension and consequently all the stress of weight-bearing comes upon the bone graft.

Fig. 3-B: Eighteen months later, the strain upon the bone graft resulted in its fracture with collapse of the vertebral bodies into one another. This was followed by an exacerbation of activity of the disease which was treated by further recumbency and a second bone graft. The fracture in the first bone graft healed spontaneously, with ultimate bony fusion.

Fig. 3-C: The ultimate result after the exacerbation had been treated by a further period of recumbency and another bone graft. Healing by bony ankylosis.

#### COMPLICATIONS ARISING DURING TREATMENT

Since Pott's disease is a manifestation of the invasion of the blood stream by tubercle bacilli, not unnaturally it is frequently accompanied by other blood-borne foci of tuberculosis as well as by complications peculiar to the disease itself. The systemic nature of the infection which produces Pott's disease requires emphasis. Its very nature indicates that we are dealing with a blood-borne infection and must plan our treatment accordingly.

We have listed in the following paragraphs and in Table IV the complications of our cases in the order of their frequency.

*Abscess* occurred at some stage in 90 per cent. of our patients. In the case of psoas abscess the diagnosis may be obvious, but the mediastinal abscess of dorsal Pott's disease can be recognized only by x-ray.



FIG. 4-A



FIG. 4-B

Failure of healing and extension of the disease. Roentgenograms of thoracic Pott's disease, taken at an interval of two years, showing extension of the disease beyond the area which had been grafted and probably indicating that fusion did not occur over a sufficient number of vertebrae.

It is our feeling that recognition and treatment of the abscess are an important part of the treatment of Pott's disease. Wherever the abscess is accessible we have treated it by repeated aspiration in order to achieve drainage without the dangers of secondary infection. Usually this results in the disappearance of the abscess. In the exceptional case in which the abscess continues to increase in size in spite of aspiration, we have drained it through a small stab wound into an *antiseptic* dressing. The best antiseptic for this purpose is Keith's dressing which is sufficiently antiseptic to minimize the dangers of secondary infection, and the glycerine base ensures its remaining active for at least twenty-four hours. This is the principle established by Lister for treating this problem and we therefore designate it Listerian drainage.

We have gradually extended the field of aspiration and now use it for the mediastinal abscess. This must be done with x-ray supervision and is not easy, but yields valuable diagnostic information and materially aids in treatment.

*Amyloid disease* occurred in 13.75 per cent. of our cases. This perhaps seems a high rate. It is accounted for by the fact that we have made the diagnosis by means of an improved Congo-red test. This has enabled us to recognize amyloid disease where otherwise it might have been unsuspected,—for example, in the absence of sinus.

*Renal or genital tuberculosis* occurred in 26.25 per cent. of our cases. This is one of the most frequent complications of Pott's disease and is

often overlooked since it may give rise to no symptoms. Only examination of the urine for tubercle bacilli can give certain indication of its presence. Since Pott's disease is a blood-borne implantation of the disease it is reasonable to expect that other hematogenous foci might accompany it. This is indeed the case; associated bone foci are not infrequent and renal tuberculosis, which also is a blood-borne focus, is much more frequent than in pulmonary tuberculosis, *per se*. Routine examination of the urine for tubercle bacilli is as much a part of the management of a case of bone and joint tuberculosis as is examination of the chest.

*Addison's disease* was present in three, or 3.75 per cent., of our eighty patients. Each case terminated fatally. This complication may easily be overlooked. Newer methods of recognition are of great value.

*Paraplegia* occurred in 16.25 per cent. of our cases. No case occurred in lumbar Pott's disease. If we exclude these, the incidence is 30 per cent. in the cases of thoracic, thoracocervical, and thoracolumbar Pott's disease. This complication is obscure in its exact pathology and difficult and uncertain in its treatment. While it is generally true that it appears while the disease in the spine is active and subsides as treatment controls the spinal disease, this is by no means always the case. In two of our patients it occurred during the period of immobilization, at a time when the active disease in the bone seemed under control. Moreover, three cases had recurrence of paraplegia, three and one-half years, five years, and ten years respectively, after the Pott's disease was apparently cured.

*Active pulmonary tuberculosis* was a complication in twenty-four cases (30 per cent.). As might be expected, pulmonary tuberculosis is a frequent and important complication of Pott's disease. In most cases it represents the primary focus from which the blood stream is infected and from which in turn the focus of Pott's disease is laid down. Of the twenty-four patients, eleven had positive sputum. In six, the pulmonary disease was so active and advanced that adequate treatment, both of the pulmonary lesion and of the Pott's disease, was impossible. Five of

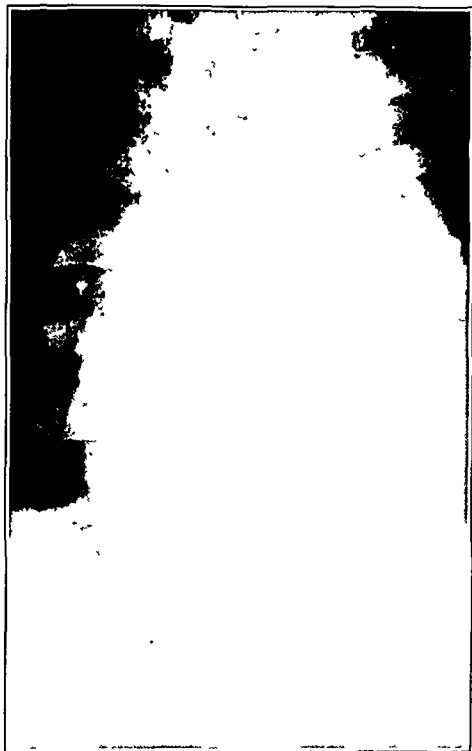


FIG. 4-C

Anteroposterior view showing the mediastinal abscess which resulted from the extension of the disease.

TABLE V  
MORTALITY IN TREATMENT OF POTT'S DISEASE

Treatment	No. of Cases	Deaths	Per Cent.
Bone-grafting .....	50	6	12.00
Conservative .....	30	17	56.67
Total .....	80	23	28.75

TABLE VI  
CAUSES OF DEATH

Cause	No. of Cases
Generalized tuberculosis .....	10
Amyloidosis .....	4
Secondary infection .....	2
Addison's disease .....	2
Renal tuberculosis .....	1
Pulmonary tuberculosis .....	1
Meningitis .....	1
Non-tuberculous (pneumonia and coronary occlusion) .....	2

these died and one recovered. Collapse therapy was attempted but was unsuccessful in two cases; of these one patient died and one recovered. Collapse therapy was successfully undertaken in four cases; one patient

TABLE VII  
RELAPSES OR SEVERE COMPLICATIONS FOLLOWING HEALING

	Grafted Group		Non-Grafted Group	
	No. of Cases	Per Cent.	No. of Cases	Per Cent.
Recurrence of Pott's disease* .....	5	10.00	6	20.00
(Cured by further treatment) .....	(2)		(2)	
Recurrence of abscess without Pott's disease .....	1	2.00	1	3.33
(Cured by aspiration and rest)				
New foci of tuberculosis elsewhere** .....	6	12.00	2	6.67
Paraplegia .....	1	2.00	3	10.00
Fracture of spinal graft (lumbosacral 8, lumbar 1) .....	9	18.00		
Death from pre-existing tuberculosis elsewhere (pulmonary 1, renal 1) .....	2	4.00		

\* Recurrence took place: (a) in the grafted area; (b) adjacent to the grafted area; (c) in a new area of the spine.

\*\* These new foci were found in the hips in three cases, in the knee in two, and in the adrenals, genito-urinary tract, and meninges, in one case each.



died, after discharge, of tuberculous bronchopneumonia. One other patient was treated by aspiration for pleural effusion. The remaining patients were treated by bed rest.

Pulmonary tuberculosis was important as a cause of death in four cases (5 per cent.). Pulmonary tuberculosis is an important factor in the course, outcome, and mortality of Pott's disease.

#### MORTALITY

The general mortality in our group of eighty cases was 28.75 per cent.

In the group of fifty patients who were treated by bone-grafting, there were six deaths (12 per cent.). Tuberculosis in various forms was the chief cause of this mortality, and, with one exception, death occurred two or more years after treatment. (See Tables V and VI.)

In the group of thirty cases treated conservatively there were seventeen deaths (56.67 per cent.). This is the direct outcome of our plan of treatment since it placed in the group for conservative treatment all cases unfit for surgery. This group consequently had a high proportion of patients seriously ill with generalized tuberculosis or secondary infection.

#### RELAPSES OR SEVERE COMPLICATIONS AFTER HEALING (TABLE VII)

*Pott's disease* recurred in eleven cases (five grafted and six non-grafted). In the grafted cases the recurrence of Pott's disease was: (a) adjacent to the grafted area in three cases; (b) in a formerly fused area, one case; (c) in an entirely new area in one case. Further treatment, including fresh areas of spine fusion, resulted in improvement or cure. In the non-grafted cases, the recurrence in two cases was treated successfully by grafting.

*Recurrence of abscess*, without evidence of fresh caries, was found in one case in each group. Both were treated successfully by aspiration and immobilization.

*New foci of tuberculosis elsewhere* were observed in eight cases (six grafted and two non-grafted). Of these foci, three were in the hip, two were in the knee, and one each occurred in the adrenals, the meninges, and the genito-urinary tract.

*Paraplegia* was present after healing of the spinal lesion in four cases. Bone-grafting was done in one of these cases (2 per cent.) but not in the remaining three (10 per cent.).

*Fracture of Bone Graft* occurred in nine cases. In one case with exacerbation of activity, immobilization and a second bone graft were required. Ultimate cure resulted. The remaining eight cases had few symptoms, and required no special treatment. The fractured grafts all united.

This may seem a high incidence of fracture of the graft. It can be explained as follows: We have been diligent in the periodic review of our cases and have made careful roentgenographic scrutiny of the graft an essential part of the review. Moreover, the type of graft we use lends

itself well to visualization by roentgenogram. The large double grafts from the tibia show well, and if they are fractured this also shows more clearly than in the usual Hibbs or Albee technique. Several of the fractures were discovered only on roentgenographic review; the patients had made no complaint, and nothing in the clinical examination suggested fracture. The frequency of fracture of the graft in our series, therefore, is accounted for partly by the careful search which was made for it. The commonest site of fracture was in the area between the fifth lumbar vertebra and the sacrum, where great strain occurs. The one serious case (Figs. 3-A, 3-B, and 3-C) resulted from strain upon the graft when the spine was fused in hyperextension with the involved bodies separated by an appreciable space. We now feel that the spine should be fused with the diseased bodies in contact, even though this means the existence of a certain amount of deformity.

*Death*, from pre-existing tuberculosis elsewhere after the spinal lesion had healed, occurred in two cases,—one each from pulmonary and renal tuberculosis.

# A CRITICAL STUDY OF TUBERCULOSIS OF THE SPINE IN CHILDREN

BY LEO MAYER, M.D., NEW YORK, N. Y.

Fifteen years ago, when the country branch of the Hospital for Joint Diseases was opened, we were given an opportunity to treat tuberculosis of the spine under excellent hygienic conditions. Although the fusion operation appealed to us as a logical form of therapy, it seemed important to compare cases treated by the operative method with those in which purely conservative measures were used. Cases were therefore arranged in two groups,—those in which fusion operations were done and a control series of unoperated cases. The idea of this test was not new or original, since it had been reported by Kidner and Muro<sup>1</sup> in a small series published in 1927. Great care was taken to pair off the cases as accurately as possible with regard to duration of the disease, the number of vertebrae involved, the presence of abscess, and the age of the patient. In only one respect was there a marked difference between the two groups,—when patients were admitted with extreme cachexia and evidences of amyloidosis, operation was not done. Sixty-six cases were observed: spine fusion was done in thirty-seven, and twenty-nine were treated conservatively.

The results of fifteen years of observation are summarized as follows:

1. It is impossible to make a certain diagnosis of tuberculosis of the spine in the early stage, since other diseases may give similar symptoms, physical signs, and roentgenographic appearance. Therefore, all statistics relative to Pott's disease—our own included—should be accepted with some reserve, since in many cases the diagnosis is presumptive not positive.

2. Since the virulence of the invading tubercle bacillus and the resistance of the patient are two variables, the medical observer must be extremely cautious in attributing an early arrest of the disease to any one factor in the treatment. This applies particularly to the effect of fusion.

3. Since spine fusion involves only the laminae and the intervertebral articulations, and because the healing of the invaded bodies usually takes place by the so-called block process in which a fusion of one or more bodies occurs, the operative fusion, if performed at a stage antedating the pathological fusion of the bodies, will, if the fused laminae prevent flexion, actually tend to interfere with the natural process of healing.

4. As a matter of fact, the operative fused area does not remain fixed, but bends approximately 10 degrees or more, as is conceded by the advocates of fusion.

5. Following fusion, healing may take place without extension of the process to the adjoining vertebrae, exactly as in non-fused cases, or we may see the following:

- a. Extension of the process upward or downward to adjacent vertebrae;
- b. Persistence of old abscesses or formation of new abscesses;
- c. Healing in the first area, but reappearance of the disease in another area;
- d. Persistence of paraplegic symptoms.

In other words, exactly the same pathological changes may and do occur as in the unfused cases.

6. Tuberculosis of the spine is a local manifestation of a general disease, and, although the local treatment is important, the general treatment is far more important.

7. Despite the great advance of medical knowledge, the essentials in the general treatment of tuberculosis of the spine remain today the same as in the time of Hippocrates,—fresh air and sunlight, nutritious food, and adequate rest. I say this advisedly after a thorough trial of tuberculin treatment, splenic extract, and the Gerson-Sauerbruch diet.

8. A case of tuberculosis of the spine cannot be declared cured because of the disappearance of muscle spasm, tenderness, and pain. It is reasonable to assume a cure under the following conditions:

- a. Disappearance of abscesses or their calcification, as seen in the roentgenogram;
- b. Block formation of two or more bodies;
- c. Closure of sinuses;
- d. Absence of pain, temperature, and muscle spasm;
- e. Consistent gain in weight.

Even when all these signs are present and the patient is discharged, apparently cured, there may be a relapse. In our series there were two relapses in the operatively fused cases and one relapse in the unfused cases.

9. A relapse may show itself as:

- a. Reformation of an abscess or sinus;
- b. Appearance of paraplegic phenomena;
- c. Appearance of tuberculosis in another area of the spine.

10. In general, the lower the site of the lesion, the less the tendency to deformity. In cases involving the fourth or fifth lumbar vertebra or the fifth lumbar vertebra and the sacrum, healing occurred without any deformity. In the upper lumbar area, the deformity was slight, with or without fusion. In the thoracic region, with involvement of three or more vertebrae, more deformity occurred; this was most marked when the sixth or seventh thoracic vertebra formed the center of a focus of seven or eight vertebrae.

11. Comparing the fused cases with the unfused, we found that healing required 20 per cent. more hospital days in the operated cases than in the unoperated. It may be thought by some that this may have been

due to faulty operative technique. This may be true, but in the two relapsing post-fusion cases with spastic paraplegia in which I did a laminectomy, I found the laminae fused by a wall of bone fully one inch thick.

12. The duration of the disease varies. Mild cases are cured in two years; severe cases may last ten years; the average duration is three to five years.

13. In quiescent cases where there was no evidence of an active advancing process, particularly in cases of three or more years' duration in which four or more vertebrae were involved, the fusion operation had a definite beneficial effect. One patient described the operation as her "re-birth". In this group, patients could be discharged cured within a few months after the operation. In other words, the fusion strengthened a spine which had been structurally weakened by the tuberculous process.

14. The mortality in our series of sixty-six cases was 12 per cent. Death occurred because of tuberculous meningitis, amyloidosis, or pulmonary involvement.

15. In our series there were only one case of proved involvement of a kidney and two of the lungs. The group differs radically, therefore, from the adult cases described by Mather Cleveland.

#### CONCLUSIONS

In children under eighteen years, the fusion operation performed during the active stage of the disease does not abbreviate the course of the tuberculous process. On the other hand, when done during the reparative stage, in patients with collapse of three or more vertebrae, it has a beneficial effect in strengthening a structurally weak spine.

1. KIDNER, F. C., AND MURO, FELIPE: Comparative Results of Operative and Non-Operative Methods of Treatment of Tuberculosis of the Spine in Children. *J. Bone and Joint Surg.*, IX, 649, Oct. 1927.

# POTT'S DISEASE: THE INITIAL LESION, THE RELATIVE INFREQUENCY OF EXTENSION BY CONTIGUITY, THE NATURE AND TYPE OF HEALING, THE RÔLE OF THE ABSCESS, AND THE MERITS OF OPERATIVE AND NON-OPERATIVE TREATMENT

BY PAUL P. SWETT, M.D., BLOOMFIELD, CONNECTICUT, GEORGE E. BENNETT, M.D., BALTIMORE, MARYLAND, AND DANA M. STREET, M.D., ALBANY, NEW YORK

The basis of this paper is a clinical and statistical study of the end results in a series of 350 cases of Pott's disease. This study originally was undertaken to evaluate the relative merits of the operative and the non-operative treatment. In the course of this work many interesting phases of spinal tuberculosis have presented themselves, and, in some respects, the by-products are more important than the original project. Chief among these is the discovery of the dominant rôle of the abscess in the healing process. So marked is the apparent rôle of the abscess that the particular form of the local treatment appears to be relatively unimportant. Thus it has been found that healing only rarely occurs in the presence of an abscess, and this is even more marked if the abscess is calcified or if calcific debris remains in the vicinity of the lesion. On the other hand, healing usually promptly follows the disappearance of the abscess.

The inspiration for this study came from Dr. Bennett, who provided the background of his own extensive experience in the treatment of Pott's disease. The Eastern States Orthopaedic Club sponsored the study, and Dr. Robert I. Harris added the impetus which brought the study into focus by making available his own clinical material, which had been recorded for the purpose of critical study.

## NATURE AND SCOPE OF STUDY

Realizing that the passage of time often necessitates a downward revision of the estimate of the early results in many chronic diseases, it was decided to direct attention to the oldest available cases. Therefore, much of the material goes back twenty-five years, and no cases are included of less than five years' duration.

A representative cross section was assured by the use of cases from diverse sources.\* Geographical diversity was provided in order to secure

\* Approximately 150 cases were supplied by Dr. George E. Bennett and his associates in Baltimore; fifty cases were contributed by Dr. A. Bruce Gill in Philadelphia; eighty cases were furnished by Dr. Robert I. Harris in Toronto; and seventy-five were provided by Dr. John O'Brien of The Seaside Sanatorium in Waterford, Connecticut. Grateful acknowledgment is hereby made to these men and to the institutions which they represent,—namely, The Children's Hospital School and The Johns Hopkins Hospital in Baltimore, The University of Pennsylvania Hospital in Philadelphia, The Toronto Hospital for Consumptives at Weston, Ontario, and The Seaside Sanatorium in Waterford, Connecticut.

TABLE I  
PATIENTS BY RECORDING OF EXTENSION OF DISEASE BY CONTIGUITY

Patients	No Extension*		Extension		Questionable		Total	
	(Cases)	(Per Cent.)	(Cases)	(Per Cent.)	(Cases)	(Per Cent.)	(Cases)	(Per Cent.)
Children . . . . .	86	42.58	50	24.75	66	32.67	202	100.00
Adults . . . . .	66	60.55	7	6.42	36	33.03	109	100.00
Total . . . . .	152	48.87	57	18.33	102	32.80	311	100.00

\* The infrequency of extension is more marked in adults. The greater incidence of extension in children occurs in the thoracic area and this may be due to the conditions of treatment.

racial and environmental differentiation. This also provided clinical diversity. Hence the patients in this group were treated by many different surgeons, and, without discrimination, there are included children, adults, ward patients, and private patients. From these various sources the cases were taken in consecutive order, and every case in which a positive diagnosis could be established was used, provided that adequate data to meet the exacting demands of our records could be obtained. These requirements not only included the usual data in the history, but they also necessitated a final follow-up note, a physical examination, and a roentgenographic examination.

The data were recorded on individual abstract forms which have proved to be highly satisfactory.\*\* All of the findings were recorded on these forms by the research fellow (D. M. S.), and each case was checked in detail by the director of the study (P. P. S.), who also examined the roentgenograms in all cases and checked the histories in all doubtful cases.

This paper is restricted to a brief discussion of the following topics, together with a presentation of such statistics as bear upon these topics: (1) the definition of healing in Pott's disease, as it is applied in this study; (2) the initial lesion; (3) types of healing; (4) the abscess in Pott's disease; (5) the relative infrequency of extension of the disease by contiguity; and (6) the relative merits of operative and non-operative treatment.

#### DEFINITION OF HEALING

The necessity for a consistent definition of healing was recognized at an early stage of this work, but it required considerable time and thought to reach a conclusion as to a formula which was both satisfactory and universally applicable. It was finally decided to adopt the dictum of Percival Pott, who said that bony ankylosis was the thing aimed at in the treatment of spinal tuberculosis. It also was determined to base the presence of ankylosis upon the roentgenographic appearance. The definition

\*\* Our grateful thanks also are due to Dr. E. L. Crosby of Johns Hopkins Hospital, whose patience and ability provided for us the excellent abstract forms without which this study would have foundered in its early stages.

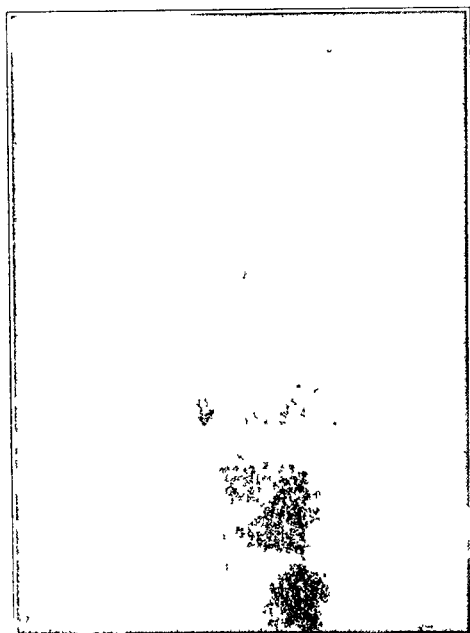


FIG. 1-A



FIG. 1-B

Healing, Type 1. Bony ankylosis between two adjacent vertebral bodies with a loss of the intervening cartilage. Deformity slight.

thus derived may be briefly stated as follows: Healing consists of the disappearance of the destructive lesion, a firm bony ankylosis between the remaining portions of the involved vertebrae, and the restoration of a normal consistency to the surrounding bone.

This definition is considered to be too rigid by many pathologists and by surgeons as well, but it must be realized that its adoption was for the purpose of recording actual healing rather than merely satisfactory clinical results. One competent pathologist suggests that, while it probably is true that granulation tissue, fibrotic material, and calcific debris may prevent bony ankylosis, this does not mean a failure of healing. According to this view, such a condition is regarded as a poor surgical result, but not a failure of healing, since the products of the inflammatory reaction are inspissated and may remain indefinitely walled off and innocuous. However, it was decided not to follow this line of reasoning because: (1) There are too many recorded cases of late abscess development and increasing deformity in the non-ankylosed; (2) the statistics thus gathered would be less reliable than the case if an inelastic standard.



us, and for this reason the figures given in Table I have been carefully scrutinized. It is probable that this scrutiny has been so rigid that the figures actually underestimate the truth of the situation.

Judging by the roentgenographic appearance, the initial lesion occurs in the body of the vertebra, where it is found in the following locations in order of frequency: (1) the metaphysis; (2) the cancellous portion of the body; (3) the periosteum; and (4) the periosteum and the metaphysis, which sometimes are simultaneously involved. It is to be noted that the periosteal process is most likely to appear on either the anterior or the posterior aspect of the vertebral body. Strikingly enough, one of the earliest roentgenographic signs is compression of the intervertebral cartilage. This often is present before there is positive evidence of bone disease. In spite of this, it is believed that the compression of the disc results from interference with its nutrition, due to underlying bone disease, and that the disc is rarely if ever primarily involved

#### TYPES OF HEALING

Because of variations in the type and the extent of the initial lesion, the age of the patient, the influence of treatment, and certain other fac-

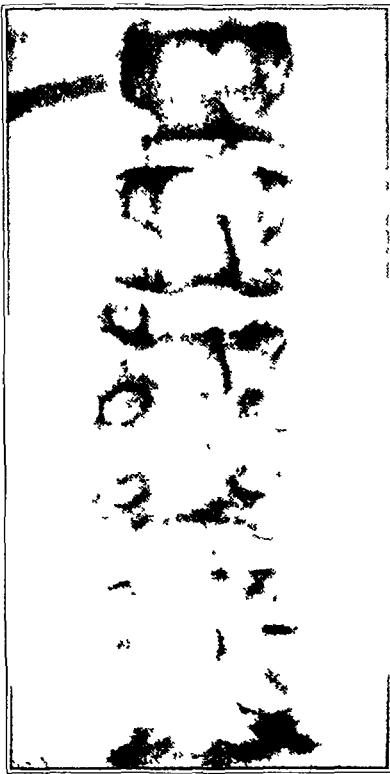


FIG. 2-A

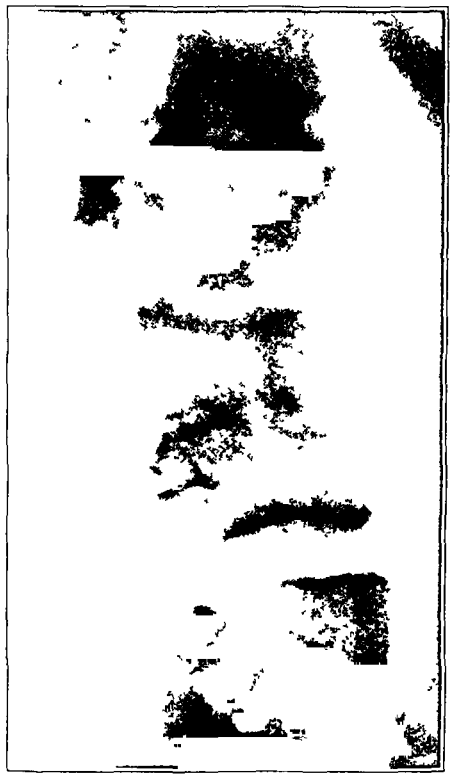


FIG. 2-B

Healing, Type 2. Bony ankylosis between two vertebral bodies with disappearance of one intervening body and the loss of two intervening cartilages. Deformity moderate.

tors, some of which are not known, the appearance of the healed spine varies widely. The chief varieties have been divided into the following four groups

1. Complete fusion of two contiguous vertebral bodies and a disappearance of the intervening disc Slight deformity occurs in this type.

2 Complete bony fusion of two vertebral bodies with an absence of one intervening body and two intervening cartilages. The deformity here is moderate.

3 Complete bony fusion of multiple vertebral bodies with a loss of multiple intervening bodies and cartilages. The deformity in this type is unrestrained and is marked by dislocations and other bizarre effects.

4 Solid bony ankylosis of portions of the opposing body surfaces, leaving a space in which the cartilage may or may not be healthy. Such

TABLE II

PERIOD BETWEEN ONSET AND REEXAMINATION AND RESULT OF TREATMENT IN CHILDREN

Period between Onset and Reexamination (Years)	Result of Treatment		
	Healing (Cases)	No Healing (Cases)	Questionable (Cases)
Under 2	0	8	1
2 to 5	2	8	0
5 to 10	20	28	10
10 to 15	18	22	1
15 to 20	7	11	6
Over 20	26	11	14
Uncertain	5	1	3
Total	78	89	35

TABLE III

PERIOD BETWEEN ONSET AND REEXAMINATION AND RESULT OF TREATMENT IN ADULTS

Period between Onset and Reexamination (Years)	Result of Treatment		
	Healing (Cases)	No Healing (Cases)	Questionable (Cases)
Under 2	0	4	0
2 to 5	1	5	0
5 to 10	15	20	8
10 to 15	5	8	8
15 to 20	6	3	5
Over 20	2	3	6
Uncertain	2	7	1
Total	31	50	28



FIG. 3-A

Healing, Type 3. Bony ankylosis between multiple bodies with a disappearance of multiple intervening bodies and cartilages. Deformity severe.

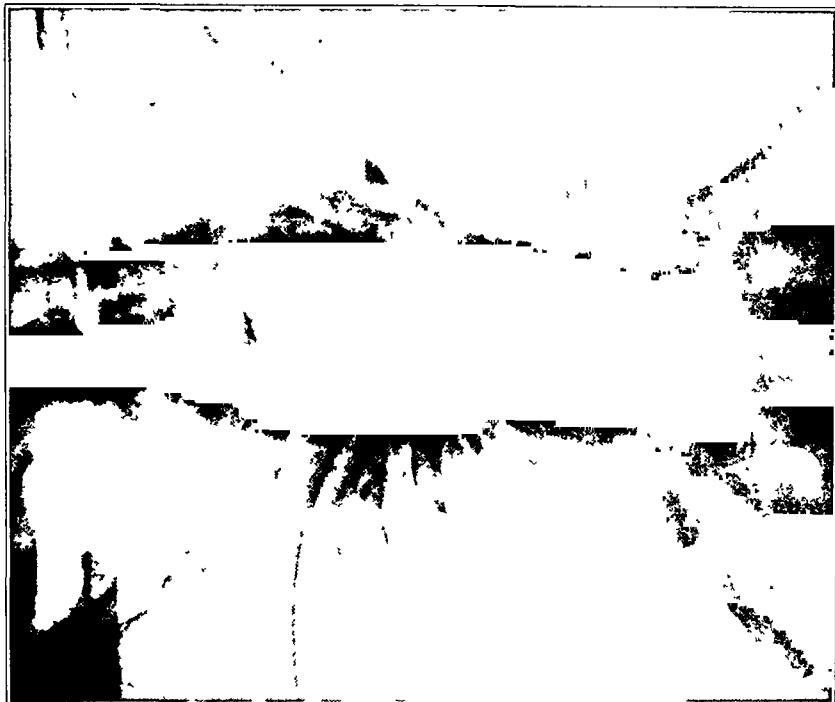


FIG. 3-B



FIG. 4-B

Partial ankylosis between two adjacent vertebral bodies with a partial loss of the

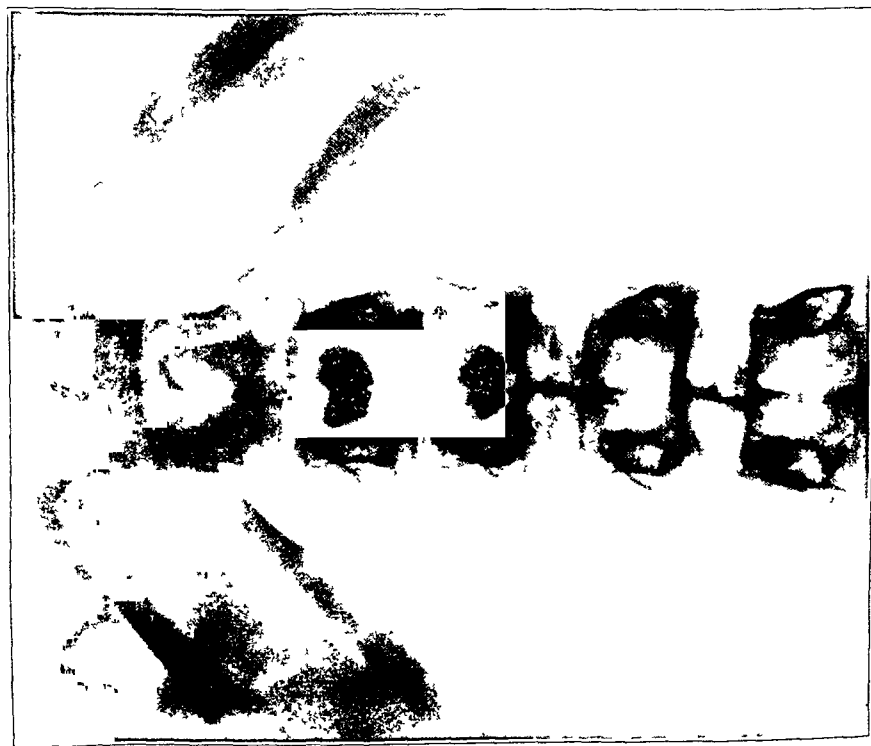


FIG. 4-A

Healing, Type 4, classified in this study as questionable. Partial ankylosis between two adjacent vertebral bodies with a partial loss of the intervening cartilage. Deformity not characteristic.



Fig 5-A

Non-healing

No bony ankylosis, and the diseased area is filled with calcific material

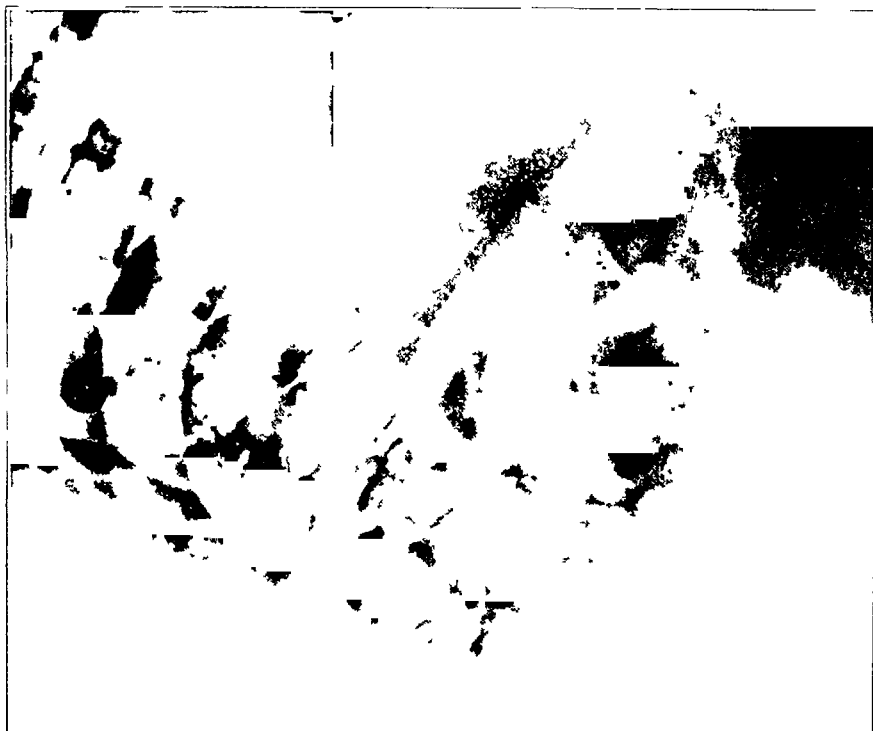


Fig 5-B

Deformity unrestrained.

a result is questionable and is so classified in this study. The deformity here may be of any grade.

An example of each of these healing types is shown under an appropriate heading in the accompanying illustrations, and for contrast there also is included an example of the sort of result which has been classified as a failure of healing.

#### ABSCCESS

We were surprised to find early in the process of reviewing these cases how constantly the abscess factor entered into the problem. Being quite unprepared for this observation, we at first thought it might be more apparent than real. The evidence continued to pile up as the work progressed, and at last there could no longer be any doubt that the abscess plays an important part in the healing of tuberculosis of the spine. This aspect of the subject therefore is presented rather extensively.

The tuberculous spinal abscess may be found as follows:

1. Beneath the strong anterior ligaments, where it is called a paravertebral abscess.

2. Within the fascial layers after it has escaped from its paravertebral location. A fascial abscess is designated by the prefix which refers

TABLE IV  
TYPE AND RESULT OF TREATMENT IN CHILDREN (UNDER THIRTEEN)

Type of Treatment	Result of Treatment						Total	
	Healing (Cases) (Per Cent.)		No Healing (Cases) (Per Cent.)		Questionable* (Cases) (Per Cent.)			
Non-operative Operative.	56	40 00	61	43 57	23	16 43	140	100 00
	22	35 48	28	45 16	12	19 36	62	100 00
Total	78	38 61	89	44 06	35	17 33	202	100 00

TABLE V  
TYPE AND RESULT OF TREATMENT IN ADULTS (OVER THIRTEEN)

Type of Treatment	Result of Treatment						Total  (Cases) (Per Cent.)	
	Healing (Cases) (Per Cent.)		No Healing (Cases) (Per Cent.)		Questionable* (Cases) (Per Cent.)			
Non-operative Operative.	7	18 92	22	59 46	8	21 62	37	100 00
	24	33 33	28	38 89	20	27 78	72	100 00
Total .	31	28 44	50	45 87	28	25 69	109	100 00

\* "Questionable" cases are neither "healing" nor "no healing", but include some arrested cases.

to its particular fascial location, such as cervical, mediastinal, extra-pleural, lumbar, or psoas.

3. Within the spinal canal, where it is an extradural abscess. Although every tubercle at some stage of its existence contains caseous material and the confluence of numerous tubercles produces a gross abscess, this term is not used until the abscess has ruptured its wall and emerged beneath the soft parts.

In any of these locations the abscess may: (1) become absorbed; (2) spontaneously evacuate itself; (3) undergo surgical evacuation; (4) become calcified; or (5) remain indefinitely without apparent change. In this last event the condition is spoken of as a persistent abscess

#### EXTENSION OF DISEASE BY CONTIGUITY

It is commonly believed that the persistence of an abscess indicates continued activity of the disease, but this is not confirmed by the observations in this study. Continued activity of the disease should be accompanied by an extension of the process, but this has been found to be relatively uncommon. Out of 311 cases in which this factor has been recorded, extension by contiguity occurred in only fifty-seven, while no

TABLE VI

COMPARISON OF PERSISTENT ABSCESS IN OPERATIVE AND NON-OPERATIVE CASES, IN CHILDREN AND IN ADULTS

Patients	Persistent Abscess					
	Operative (Cases) (Per Cent)		Non-Operative (Cases) (Per Cent)		Total (Cases) (Per Cent.)	
Children	36	35 64	65	64 36	101	100 00
Adults	21	61 76	13	38 24	34	100 00
Total	57	42 22	78	57 78	135	100 00

TABLE VII

RELATION BETWEEN HEALING AND NON-HEALING IN OPERATIVE AND NON-OPERATIVE CASES OF PERSISTENT ABSCESS IN BOTH ADULTS AND CHILDREN

Result	Persistent Abscess					
	Operative (Cases) (Per Cent)		Non-Operative (Cases) (Per Cent.)		Total (Cases) (Per Cent)	
Healing	8	14 04	18	23 08	26	19 26
No healing	33	57 89	47	60 26	80	59 26
Questionable	16	28 07	13	16 66	29	21 48
Total	57	100 00	78	100 00	135	100 00

extension was recorded in 152 (Table I). The force of these figures is emphasized by the fact that in the entire series an abscess was recorded in 232 cases, and 135 of these were of the persistent variety.

#### CONCLUSIONS DRAWN FROM THIS STUDY

For the sake of brevity and with no intention of being dogmatic, the results of this study, which are included in this report, are presented in the form of conclusions, most of which are substantiated by statistics.

##### *First Conclusion*

A. The treatment of spinal tuberculosis is not satisfactory because:

1. After an indefinite and unpredictable length of time the lesion may heal, but in a disappointingly large number of cases healing fails to occur. Tables II and III give the figures concerning this conclusion.

2. Even when healing does occur, the length of time during which the process often remains unhealed is painfully long. This is also shown in Tables II and III.

3. The mortality is high. Although it is not yet possible to report the actual statistics in this connection, the impression which this study has given is that about one-third of the patients die within a few years.

TABLE VIII

RECORDING OF ABSCESS AND RESULT OF TREATMENT IN CHILDREN

Abscess	Result of Treatment						Total	
	Healing (Cases) (Per Cent.)		No Healing (Cases) (Per Cent.)		Questionable (Cases) (Per Cent.)			
Recorded . . . .	46	29 68	79	50 97	30	19 35	155	100 00
Not recorded . .	16	72 73	5	22 72	1	4 55	22	100 00
Total	62	35 03	84	47 46	31	17 51	177	100 00

TABLE IX

RECORDING OF ABSCESS AND RESULT OF TREATMENT IN ADULTS

Abscess	Result of Treatment						Total	
	Healing (Cases) (Per Cent.)		No Healing (Cases) (Per Cent.)		Questionable (Cases) (Per Cent.)			
Recorded .	21	27 27	44	57 14	12	15 59	77	100 00
Not recorded. .	3	42 86	2	28 57	2	28 57	7	100 00
Total	24	28 57	46	54 76	14	16 67	84	100 00



TABLE X  
PERSISTENCE OF ABSCESS AND RESULT OF TREATMENT IN CHILDREN

Abscess	Result of Treatment						Total	
	Healing (Cases) (Per Cent )		No Healing (Cases) (Per Cent )		Questionable (Cases) (Per Cent )			
Persistent	21	20 79	59	58 42	21	20 79	101	100 00
Not persistent	25	46 29	20	37 04	9	16 67	54	100 00
Total	46	29 68	79	50 97	30	19 35	155	100 00

TABLE XI  
PERSISTENCE OF ABSCESS AND RESULT OF TREATMENT IN ADULTS

Abscess	Result of Treatment						Total  (Cases)(Per Cent )	
	Healing (Cases) (Per Cent )		No Healing (Cases) (Per Cent )		Questionable (Cases) (Per Cent )			
Persistent	5	14 71	21	61 76	8	23 53	34	100 00
Not persistent	16	37 21	23	53 49	4	9 30	43	100 00
Total	21	27 27	44	57 14	12	15 59	77	100 00

TABLE XII  
CORRELATION OF HEALING AND NON-HEALING IN THE ENTIRE SERIES WITH HEALING  
AND NON-HEALING IN CASES OF RECORDED ABSCESS

	Result of Treatment						Total  (Cases) (Per Cent )	
	Healing (Cases) (Per Cent )		No Healing (Cases) (Per Cent )		Questionable (Cases) (Per Cent )			
Entire series	109	35 04	139	44 69	63	20 26	311	100 00
Abscess recorded	67	28 88	123	53 02	42	18 10	232	100 00

TABLE XIII  
OCCURRENCE OF FASCIAL ABSCESS AND RESULT OF TREATMENT IN CHILDREN

Fascial Abscess	Result of Treatment			Total (Cases)
	Healing (Cases)	No Healing (Cases)	Questionable (Cases)	
Occurred ..	17	38	11	67
Did not occur	29	41	19	88
Total	46	79	30	155

TABLE XIV

OCCURRENCE OF FASCIAL ABSCESS AND RESULT OF TREATMENT IN ADULTS

Fascial Abscess	Result of Treatment			Total (Cases)
	Healing (Cases)	No Healing (Cases)	Questionable (Cases)	
Occurred.....	15	28	9	52
Did not occur.....	6	16	3	25
Total.....	21	44	12	77

TABLE XV

DISPOSITION OF ABSCESS AND RESULT OF TREATMENT IN CHILDREN

Disposition of Abscess	Result of Treatment			Total (Cases)
	Healing (Cases)	No Healing (Cases)	Questionable (Cases)	
Spontaneous disappearance.....	17	2	4	23
Spontaneous evacuation.....	5	6	2	13
Aseptic evacuation.....	1	6	2	9
Incision and drainage.....	6	4	2	12
No change.....	10	53	10	73
Questionable.....	7	8	10	25
Total.....	46	79	30	155

*Second Conclusion*

A. As determined by the incidence of healing, there is no advantage in the operative treatment over the non-operative. This is shown in Tables IV and V.

B. No essential difference has been determined between the merits of the various forms of posterior spinal bridging. This is an impression and has not yet been subjected to statistical analysis.

C. The persistent abscess is associated with a high percentage of failure of healing. Hence it is important to note that in the operative group there is a smaller number of cases of persistent abscess. This is shown in Table VI, and it may be a point in favor of operative treatment. However, this idea is somewhat invalidated by the finding that in the 135 cases in which there was a persistent abscess the non-operative treatment showed 23.08 per cent. of healing against only 14.04 per cent. for the operative group. This is set forth in detail in Table VII.

*Third Conclusion*

A. The existence of an abscess at some stage of the disease is found

TABLE XVI

DISPOSITION OF ABSCESS AND RESULT OF TREATMENT IN ADULTS

Disposition of Abscess	Result of Treatment			Total (Cases)
	Healing (Cases)	No Healing (Cases)	Questionable (Cases)	
Spontaneous disappearance	3	5	0	8
Spontaneous evacuation	1	5	1	7
Aseptic evacuation	8	12	3	23
Incision and drainage	3	4	1	8
No change	4	16	5	25
Questionable	2	2	2	6
Total	21	44	12	77

to be the dominant factor in the healing of Pott's disease. Tables VIII and IX show the positive nature of this conclusion.

B. The persistence of an abscess is accompanied by a serious adverse effect on healing. It is to be noted that a persistent abscess usually is a calcified abscess. Tables X and XI give the basis for this significant conclusion.

C. The adverse effect of the abscess is evident even when comparing the figures for the entire series with those in which an abscess was recorded, as is done in Table XII

TABLE XVII

CORRELATION OF HEALING AND NON-HEALING FOLLOWING DISPOSAL OF ABSCESS WITH RESULTS WHEN NO CHANGE OCCURRED

	Healing (Per Cent)	No Healing (Per Cent)	Questionable (Per Cent.)	Total (Per Cent)
Disposal of abscess	42 72	42 72	14 56	100 00
No change	14 29	70 41	15 30	100 00

TABLE XVIII

CORRELATION OF RESULTS FOLLOWING DISPOSAL OF ABSCESS WITH THE RESULTS IN THE ENTIRE SERIES

	Healing (Per Cent)	No Healing (Per Cent)	Questionable (Per Cent)	Total (Per Cent)
Entire series	35 05	44 69	20 26	100 00
Disposal of abscess.	42 72	42 72	14 56	100 00

TABLE XIX  
PRESENCE OF SINUS \* AND RESULT OF TREATMENT IN CHILDREN

Presence of Sinus	Result of Treatment						Total	
	Healing		No Healing		Questionable			
	Cases	Per Cent.	Cases	Per Cent.	Cases	Per Cent.	Cases	Per Cent.
Sinus under one year.	3	30.00	3	30.00	4	40.00	10	100.00
Sinus over one year.	4	16.00	13	52.00	8	32.00	25	100.00
Uncertain duration.	7	53.85	4	30.77	2	15.38	13	100.00
No sinus. . . . .	20	30.30	37	56.06	9	13.64	66	100.00
Questionable. . . . .	12	29.27	22	53.66	7	17.07	41	100.00
Total. . . . .	46	29.68	79	50.97	30	19.35	155	100.00

\* A sinus was present in 30.43 per cent. of the healed cases and in 25.32 per cent. of the unhealed cases. There was no sinus in 43.48 per cent. of the healed cases and in 46.84 per cent. of the unhealed cases.

D. During the preliminary review of the cases it was our impression that the adverse effects of the abscess were mitigated by gravitation, but this idea is not confirmed by the figures shown in Tables XIII and XIV.

E. The spontaneous disappearance of an abscess is followed by an increased incidence of healing. This is particularly marked in children, as is shown in Tables XV and XVI.

F. Healing is not especially influenced by the spontaneous evacuation of the abscess, as is indicated by the figures in Tables XV and XVI.

G. The results following aseptic evacuation and those after incision and drainage are not significantly different. This also is shown in Tables XV and XVI.

H. Disposal of the abscess by a combination of all methods gives an improvement in the incidence of healing. This is in sharp contrast to

TABLE XX  
PRESENCE OF SINUS \* AND RESULT OF TREATMENT IN ADULTS

Presence of Sinus	Result of Treatment						Total	
	Healing		No Healing		Questionable			
	Cases	Per Cent.	Cases	Per Cent.	Cases	Per Cent.	Cases	Per Cent.
Sinus under one year.	5	55.56	2	22.22	2	22.22	9	100.00
Sinus over one year.	0	0.00	9	81.82	2	18.18	11	100.00
Uncertain duration.	3	23.08	9	69.23	1	7.69	13	100.00
No sinus.....	12	31.58	20	52.63	6	15.79	38	100.00
Questionable.....	1	16.66	4	66.68	1	16.66	6	100.00
Total.....	21	27.27	44	57.14	12	15.59	77	100.00

\* A sinus was present in 38.09 per cent. of the healed cases and in 45.45 per cent. of the unhealed cases. There was no sinus in 57.14 per cent. of the healed cases and in 45.45 per cent. of the unhealed cases.

TABLE XXI

CORRELATION OF HEALING AND NON-HEALING IN SINUS CASES WITH RESULTS FOR ENTIRE SERIES

	Healing (Per Cent)	No Healing (Per Cent)	Questionable (Per Cent)	Total (Per Cent)
Entire series	35 05	44 69	20 26	100 00
Sinus recorded	27 16	49 38	23 46	100 00

TABLE XXII

COMPARISON OF RESULTS FOLLOWING SINUS WITH RESULTS FROM PERSISTENT ABSCESS

	Healing (Per Cent)	No Healing (Per Cent)	Questionable (Per Cent)	Total (Per Cent)
Persistent abscess	19 26	59 26	21 48	100 00
Sinus recorded.	27 16	49 38	23 46	100 00

TABLE XXIII

COMPARISON OF OCCURRENCE OF HEALING AND NON-HEALING BETWEEN THORACIC AND LUMBAR AREAS IN ALL AGE GROUPS

Area	Healing (Cases) (Per Cent.)		No Healing (Cases) (Per Cent.)		Questionable (Cases) (Per Cent.)		Total (Cases) (Per Cent)	
Thoracic	54	35 06	66	42 86	34	22 08	154	100 00
Lumbar	43	37 72	50	43 86	21	18 42	114	100 00

what is found when no such disposal of the abscess is induced or occurs. This important finding is shown in Table XVII.

I. Contrasting the results following disposal of the abscess with the results for the series as a whole, as is done in Table XVIII, it is again evident that the abscess plays a dominant rôle in healing.

#### Fourth Conclusion

A. The existence of a sinus does not materially affect the incidence of healing, but it has not yet been determined what effect sinus formation has upon mortality. Tables XIX and XX give the relation between healing and non-healing in sinus cases. Table XXI shows the correlation between healing and non-healing in sinus cases and the results for the series as a whole.

B. From the standpoint of healing alone, it apparently is better to have a sinus than it is to have a persistent abscess. This is shown in Table XXII.

#### Fifth Conclusion

A. Healing is proportionately more frequent in lumbar lesions than

TABLE XXIV

COMPARISON OF OCCURRENCE OF HEALING AND NON-HEALING BETWEEN THORACIC AND LUMBAR AREAS IN CHILDREN

Area	Healing		No Healing		Questionable		Total	
	(Cases)	(Per Cent.)	(Cases)	(Per Cent.)	(Cases)	(Per Cent.)	(Cases)	(Per Cent.)
Thoracic	43	35 53	57	47 11	21	17.36	121	100 00
Lumbar . . .	28	45 91	25	40 98	8	13.11	61	100.00

it is in thoracic lesions. Probably there are several factors which influence this matter, but it is assumed that the most important factor is the greater facility of gravitation of the abscess in the lumbar region. The basis for this conclusion is found in Table XXIII.

B. The frequency of healing in the lumbar area as compared to the thoracic region is marked in children, as is indicated in Table XXIV.

## SUMMARY

1. This study shows that the treatment of spinal tuberculosis is not satisfactory, because healing as here defined occurred in only 35 per cent. of the cases studied, while in 45 per cent. of these cases healing failed to occur. Even if the 20 per cent. of questionable results is credited to the healed group, this still leaves the chance of healing only a little more than even.

2. In general, the operative treatment offers no advantage over the non-operative plan, since it is found that healing occurred in 34 per cent. of the cases operated upon and in 36 per cent. of those treated without posterior spinal bridging.

3. The dominant factor in the healing of Pott's disease lies in the occurrence, the behavior, and the disposal of the abscess. While healing occurred in 35 per cent. of the total cases, it only took place in 19 per cent. of the cases in which a persistent abscess was recorded. The dominance of the abscess is further shown by the finding that in all cases in which an abscess was recorded the percentage of healing following disposal of the abscess increased to 59 per cent.

4. The evidence inescapably points to the conclusion that the greatest need is further study of the abscess factor. To improve the results of treatment it is essential that there should be a better understanding of the nature of the abscess. There is need for knowledge of the constitutional and local factors which influence the occurrence and the disposal of the abscess. There also is need for some understanding of the conditions which prevent abscess formation and for the development of those techniques which will be most useful for dealing with the persistent abscess.

5. Until these basic matters are understood, it is probable that it would be good surgical practice to undertake early aseptic evacuation of the abscess wherever it may be located.

# The Journal of Bone and Joint Surgery

## THE TREATMENT OF CLAW-FOOT \*

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The subject of claw-foot (pes cavus, hollow-foot, etc.) has been so well covered in the literature, especially during the last twenty years, that it is unnecessary and, of course, impossible to review the condition in detail. The object of this paper is merely to outline those features which seem of major importance, and to discuss from personal experience one system of treatment which seems to be fairly satisfactory although in no way new.

A definition of claw-foot is difficult, as the various contributions and attempted classifications show, but the so-called idiopathic type appears to be the true form. Although frequently the underlying cause is evident, there seems to be no reason for subdividing the cases, unless one desires to say that certain of them are congenital in cause and the rest acquired. The deformity is largely, if not entirely, one of the forefoot which has dropped,—usually because of an ill-defined weakness of some of the muscle groups—with resulting cavus deformity (Fig. 1). Secondary to this, there is the typical contracture of the toes which, except in long-standing, severe cases, disappears when the cavus is obliterated. This is demonstrated in the milder cases when pressure under the ball of the foot flattens out the arch. All grades of cavus are seen, ranging from those of such slight degree that a distinction between a deformed foot and a simple high arch is difficult, to those advanced cases where there are large callosities or even ulcers under the heads of the metatarsals, marked cocking of the toes with dislocation at the metatarsophalangeal joints, and an excessive degree of cavus with extreme contracture of the plantar structures. In the mild or early cases the cavus disappears when the weight is put on the foot or when, as mentioned above, pressure with the hand is placed under the heads of the metatarsals. In others the deformity becomes more fixed, and the heightened arch and the cocked

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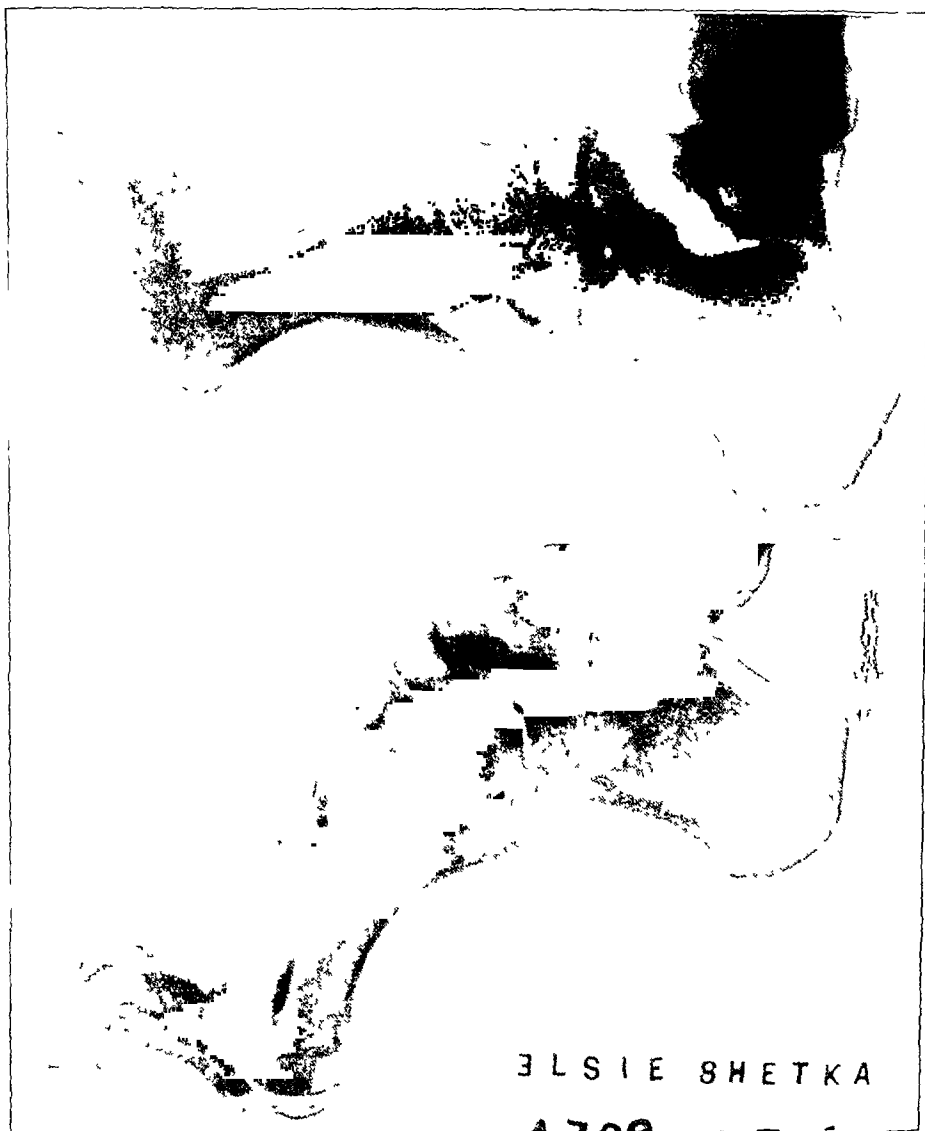


FIG. 1

Claw-foot in extreme of dorsal flexion and plantar flexion, showing that deformity is anterior only, and that there is no contracture posteriorly.

toes do not disappear on weight-bearing. Because of this, as growth takes place, the individual bones in the foot become intrinsically deformed and a true bony cavus is present which varies in degree with the individual case. Although many cases tend to progress, we find stationary cases of all grades, and the better results, following any but the most radical treatment, are probably in this group.

Etiologically we know that the deformity of claw-foot can be due to several underlying causes, but that apparently all of these result in some weakness or interference with the function of certain muscles in the foot. The central nervous system is, therefore, the site of the underlying pathology in most cases, and certainly spina bifida occulta is one of the



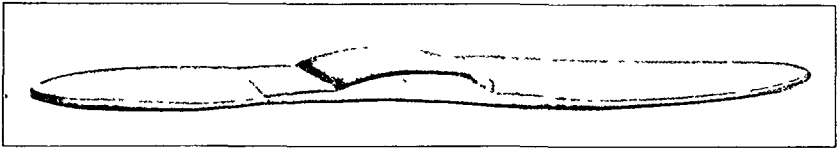


FIG. 2

Insole with anterior arch bar.

main factors in many individuals, although infantile paralysis claims a fair number of cases. The rarer factors are certain myelodysplasias, Friedreich's ataxia, multiple sclerosis, progressive muscular dystrophies, etc.

The mechanism of this deformity, why the forefoot drops and the plantar structures become contracted, has been discussed and explained by many authors, but never to the complete satisfaction of all surgeons, although there is probably some grain of truth in all of the theories. This ignorance of the exact mechanism which is called into play to cause a cavus emphasizes the need for further studies, and makes the deformity one of peculiar interest to many of us. Weakness of the interossei, lumbricales, and other intrinsic muscles of the foot has been the usual explanation, but there are anatomical reasons why this cannot be entirely accepted. It would seem that weakness of the tibialis anterior muscle, without involvement of the toe extensors, might have some bearing on the formation of the deformity, and certainly a strongly pulling or poorly opposed peroneus longus muscle can accentuate the cavus.

It is apparent, therefore, from all that has been said, that, in itself, a claw-foot is not an entity, but merely a symptom of an underlying condition. The deformity, of course, is frequently the only recognizable symptom present.

Regardless of underlying causes, with some apparent exceptions, of course, the deformity, in whatever stage we see it, needs treatment if disability is present. We must remember, however, that many individuals, with the milder degrees of cavus, go through life with little trouble other than the use of extra caution in the fitting of their shoes. Therefore, all cases do not need active or radical care. It is when the contractures are such

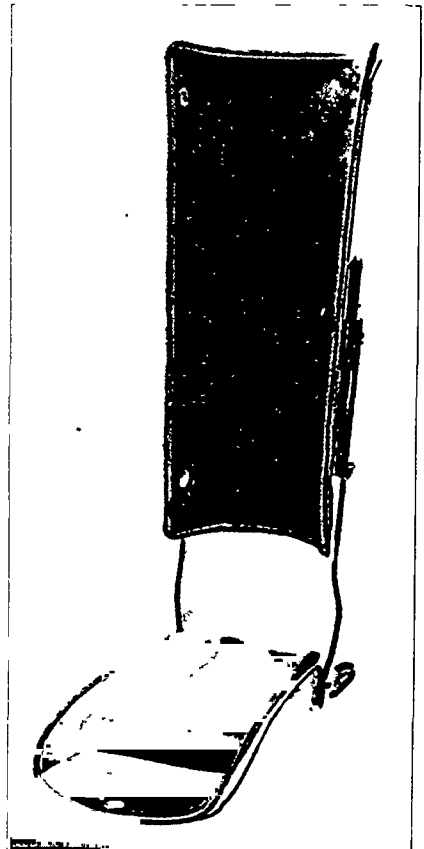


FIG. 3

Night splint with anterior arch bar.

that the feet become painful, and callosities develop under the heads of the metatarsals and over the contracted toes, that real crippling occurs. It should be our aim to prevent, if possible, such crippling by well directed early treatment. The object of ideal treatment is, of course, to correct the cavus and prevent its recurrence. Any method used must at least work toward these ends with the realization that complete attainment is probably never possible. Treatment in most cases is started in childhood or early adolescence.

The following procedures, all of which are familiar to you, are reviewed in order to show their adherence to the above principles, and the systematic way in which they can be utilized in the treatment of claw-foot from the mild to the very severe types.

It is evident that if, in the early or mild stage of deformity, the permanent contracture of the plantar structures can be prevented, the cavus, with the accompanying clawing of the toes, can be kept to a minimum. Although efforts along this line are not always successful they should be given a fair trial.

The routine used is as follows: daily repeated manipulations with flattening of the arch and stretching of the plantar structures; exercises to strengthen the dorsiflexors of the foot without allowing cocking of the toes; the use of an anterior arch bar in the shoe or, better yet, an insole with an anterior bar incorporated in it (Fig. 2); the use of a night splint, which also has a bar, to bring pressure back of the metatarsal heads and thus counteract the cavus-forming forces (Fig. 3).

In more advanced cases where the clawing is already fixed but where the deformity is not severe, treatment of a more radical nature, which

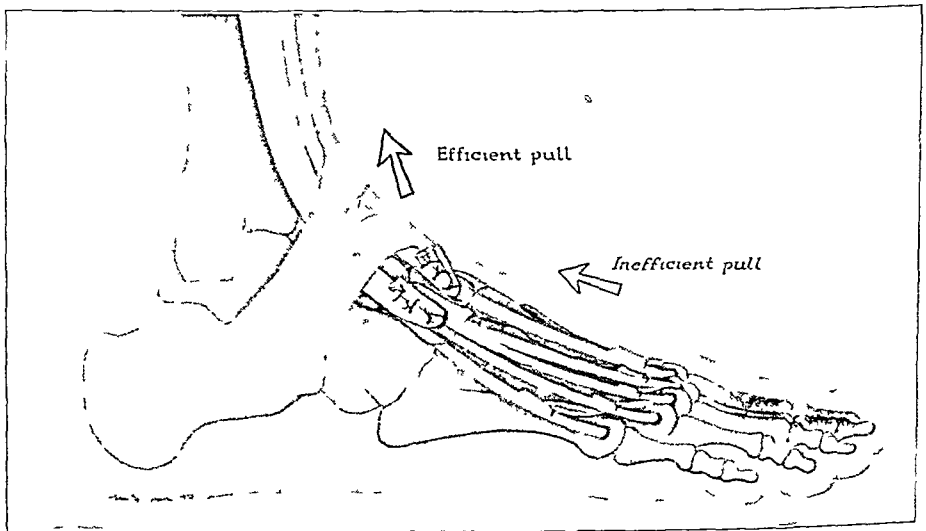


FIG 4

Diagram shows how the transplanted extensors of the toes act to the greatest advantage as dorsiflexors of the foot when placed into the cuneiform bones. The loss of power and inefficiency of the pull when the tendons lie parallel to the metatarsals after transplantation to the metatarsal heads are obvious.

must first be directed toward correction of the deformity, is needed.

The procedures used to accomplish this are two in number: (1) In the simpler cases a subcutaneous plantar fasciotomy with wrenching of the foot is sufficient. (2) More resistant cases need complete freeing of the plantar structures by the os calcis stripping operation of Steindler.

A plaster-of-Paris dressing is applied after either of these operations with the foot held as flat as possible, but with great care taken that the heads of the first and fifth metatarsal bones are under no undue pressure. After three weeks the plaster can be removed, physiotherapy started, and the routine described in the mildest cases followed.

A few cases seem to need nothing more than this, but in the majority some operation is needed to prevent the recurrence of the deformity—our second principle of treatment—as, of course, the causative factors usually are still acting. For this the modified procedure of Hibbs is used.

In brief, this consists in transplanting the tendon of the extensor hallucis longus muscle and the four tendons of the extensor digitorum longus muscle proximally into the cuneiform bones, so that their pull will reenforce the tibialis anterior as efficiently as possible in dorsiflexing the ankle. There is no logical reason for transplanting these tendons into the heads or necks of the metatarsals, as has been described by several surgeons, because, in addition to the tediousness of this procedure, there is a loss of power when the tendons lie parallel to the parts they are endeavoring to lift (Fig. 4). The illustrations show the technique of the operation and need little elaboration (Figs. 5, 6, 7, and 8). After removal of the long extensors from the toes, the smaller toes function sufficiently well, but the great toe will drop; therefore, the interphalangeal joint of the hallux must be ar-

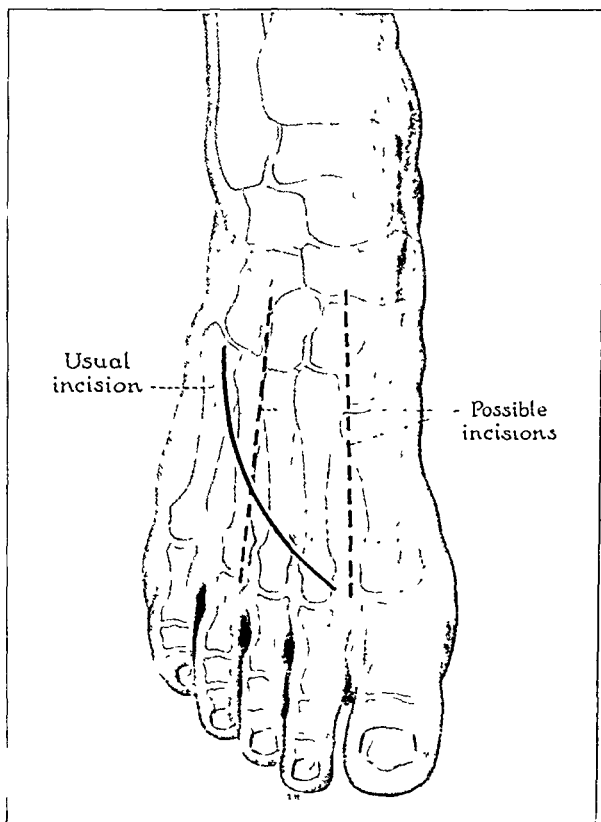


FIG. 5

Modified Hibbs transplantation, showing approximate line of incision. Two longitudinal incisions have also been tried and can be used if desired.

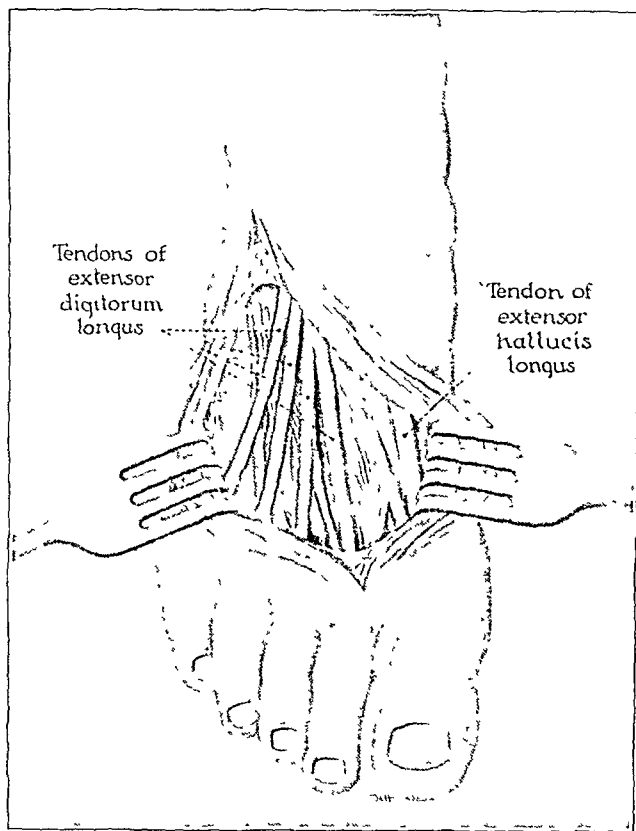


FIG. 6

Incision shown in Fig. 5 retracted to show long extensors of the toes. The vessels and nerves have been omitted for the sake of clearness.

though it appears to be theoretically sound if used in younger individuals with no great intrinsic bone deformity, the author has had no experience with this operation.

If bone deformity of any marked degree is present, the cavus cannot be corrected by releasing the plantar structures and wrenching the foot. It is then that removal of a wedge of bone is indicated as the only possible way of making the foot symptomatically less disabling, and anatomically more normal in appearance. It has never seemed justifiable to the author to remove this dorsal wedge from the neck of the astragalus or to destroy the talonavicular or calcaneocuboid joints, so for many years a so-called anterior-tarsal-wedge osteotomy has been used (Fig. 9). This preserves the lateral motion of the foot, correcting the deformity where it should be corrected, and gives as a result not only a fairly normal-appearing foot, but also one which is functionally excellent. If a wedge of bone which destroys the midtarsal joint is to be removed, a complete arthrodesis should be performed at the same time. It is, however, to prevent this loss of function that the anterior-wedge osteotomy is advocated.

A longitudinal incision is made on the dorsum of the foot and carried down between the tendons to the bone, in much the same way as in the

throdesed. A tenodesis of the distal stump of the extensor hallucis longus into the first metatarsal is sometimes used in place of the arthrodesis, but the latter is to be preferred in patients over ten or twelve years of age. The post-operative plaster dressing is removed after six weeks, and active physiotherapy is started. Weight-bearing is allowed in a shoe—previously described—with an anterior heel or its equivalent.

The simple transplantation of the peroneus longus tendon to the insertion of the brevis, as described by Bentzon, may accomplish what we are after in some cases, but, al-

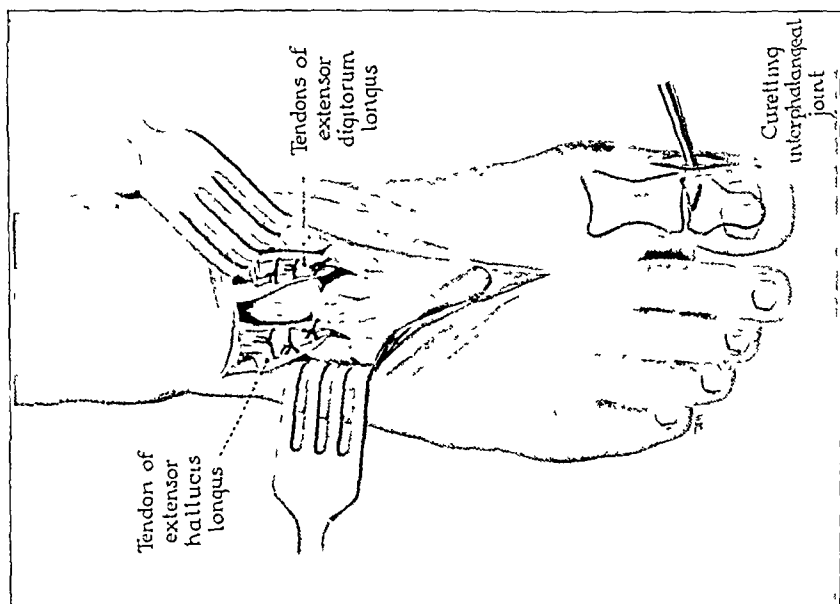


Fig. 8

The tendons shown in Fig. 7 have been passed through the tunnel in the cuneiform bones, the extensor digitorum longus bundle from the lateral to the medial side, and the extensor hallucis longus in the opposite direction. The tendons are held in place by interrupted sutures, the distal one on each side passing through the periosteum. Through a small medial incision the interphalangeal joint of the great toe is curetted in order to initiate ankylosis.

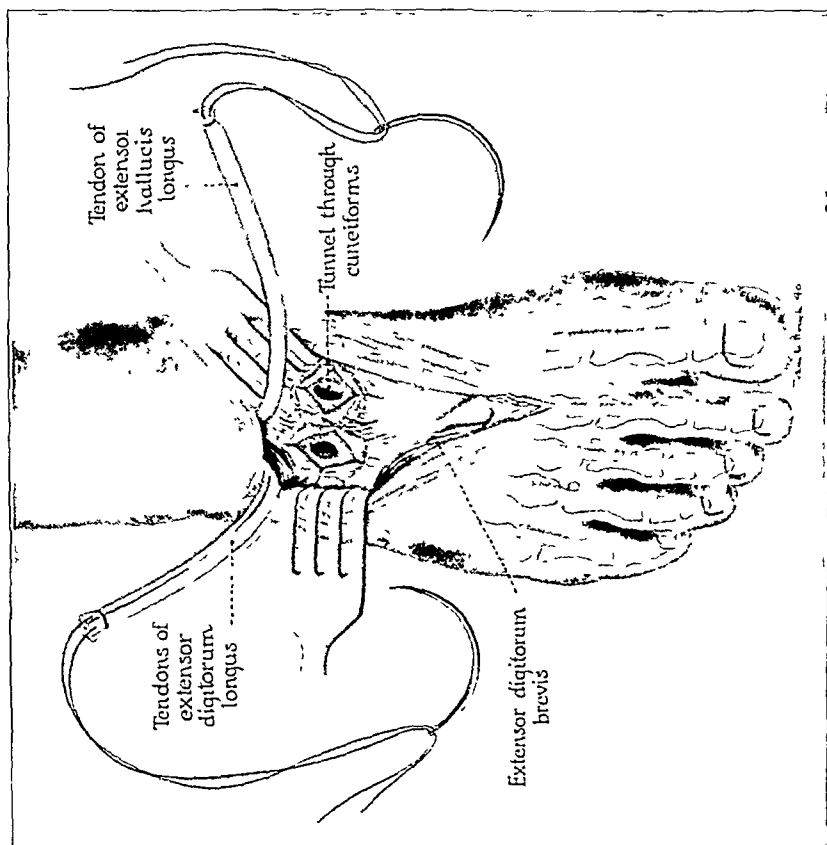


Fig. 7

The tendons shown in Fig. 6 have been cut and the four slips of the extensor digitorum longus held together in one bundle by a suture of silk or chromic catgut. The tendon of the extensor hallucis longus has a similar suture attached to it. The tunnel in the cuneiform bones has been drilled after the periosteum has been scraped away from the crucial incisions.

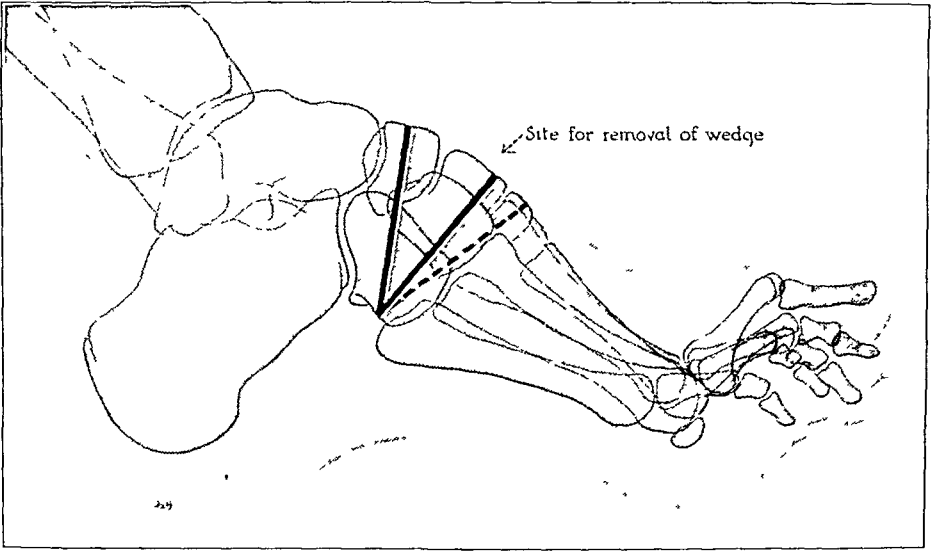


FIG. 9

A diagrammatic representation of the foot to show location of wedge in anterior-tarsal-wedge osteotomy. Note that the proximal cut is anterior to the midtarsal joint.

tendon transplantation described. The anterior tarsal region is then exposed subperiosteally as far as possible, a knife being generally used for this dissection. When the bones have been identified, a nearly vertical osteotomy is made from near the center of the navicular and cuboid bones to the under surface of the tarsus. A second osteotomy, starting anterior to the first and connecting with it at its plantar edge, is then made, the distance from the proximal cut depending on the width of the wedge necessary in the particular case. The forefoot is then brought up out of the dropped position, thus closing the gap made by the removal of the wedge. A few interrupted sutures will close the periosteum and the skin. A plaster-of-Paris dressing is then applied which extends from the toes to just below the knee. This dressing remains on for about eight weeks, when weight-bearing without support can usually be started.

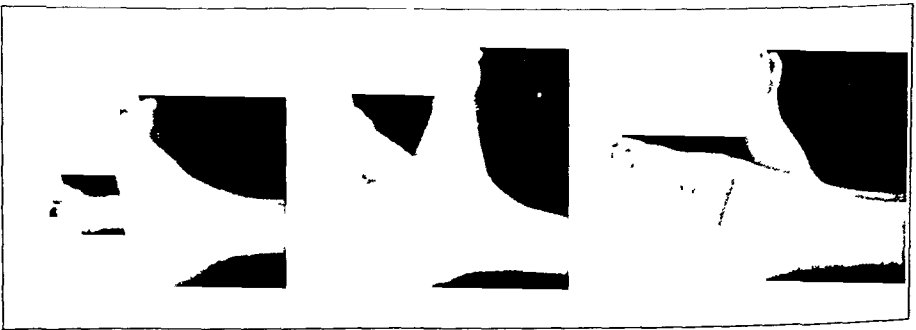


FIG. 10-A

FIG. 10-B

FIG. 10-C

C. E. Subcutaneous plantar fasciotomy and transplantation of the toe extensors. Fig. 10-A: The foot before operation. Fig. 10-B: Result two and one-half months later. Fig. 10-C: Result three years later.

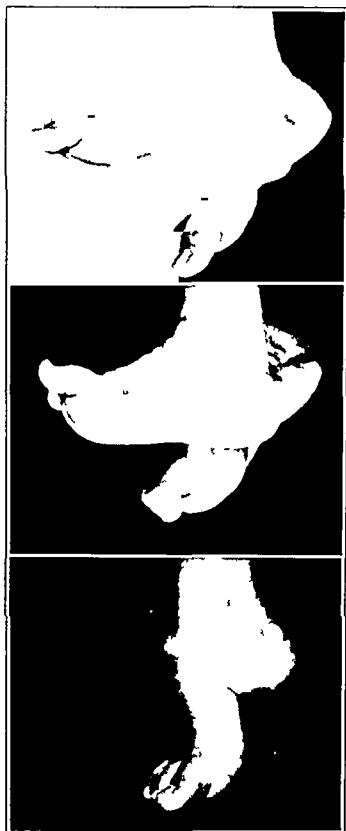


Fig. 11-B

Fig. 11-C

Fig. 11-D

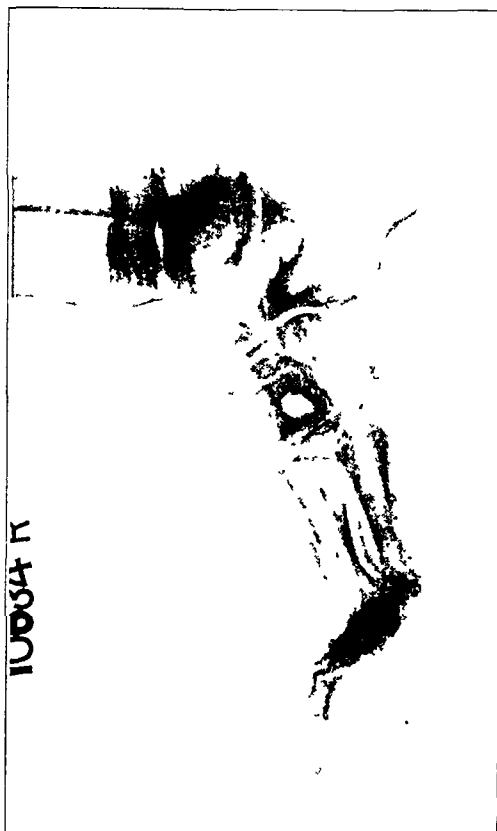


Fig. 11-E

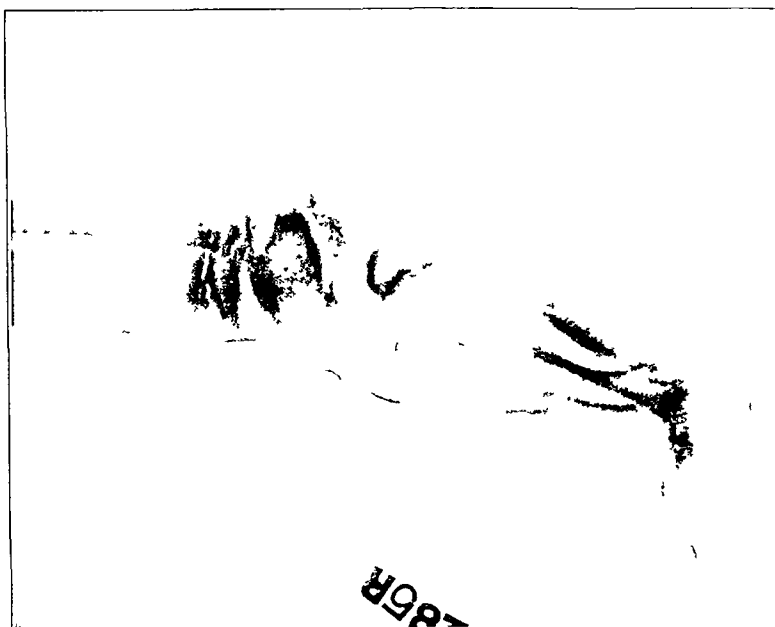


Fig. 11-A

Fig. 11-A F. L. X-ray of claw-foot before operation.

Fig. 11-B: Claw-foot before operation.

Fig. 11-C: Same foot after Steindler's operation.

Fig. 11-D: After transplantation of toe extensors

Fig. 11-E: Roentgenogram after operation.

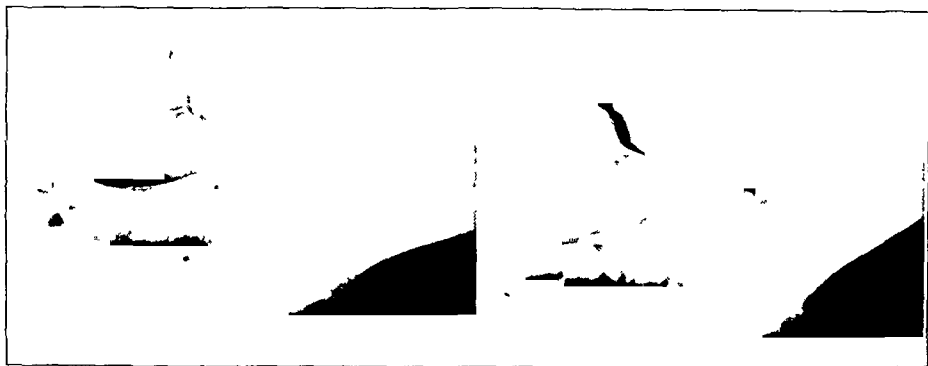


FIG. 12-A

FIG. 12-B

W. S. Claw-foot before operation and three years after transplantation of toe extensors.

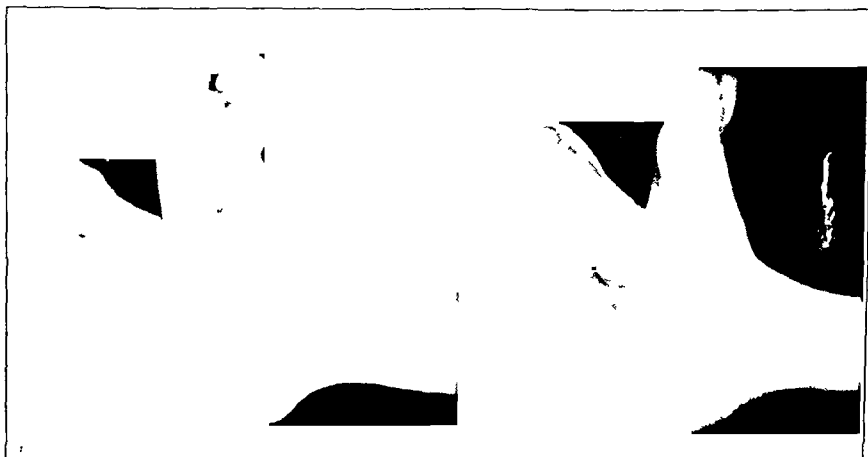


FIG. 13-A

FIG. 13-B

R. H. Moderate claw-foot before and after anterior-tarsal-wedge osteotomy.

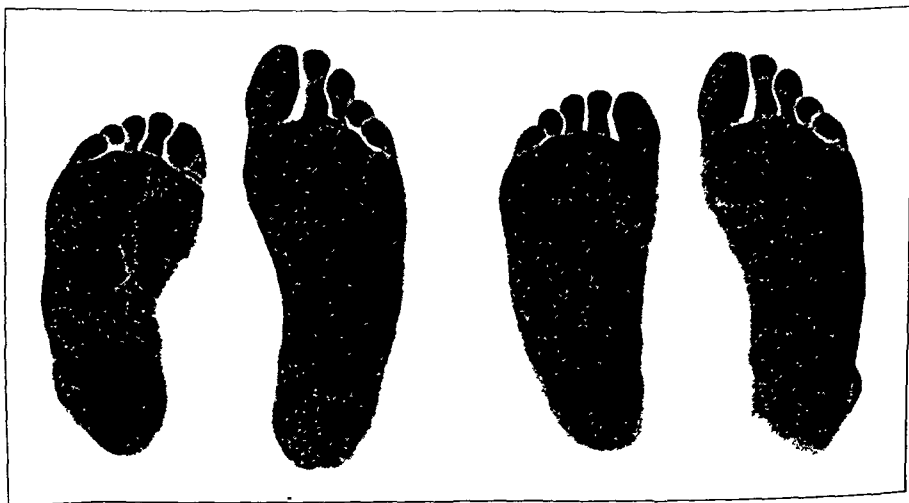


FIG. 13-C

FIG. 13-D

R. H. Soles of feet before and after removal of anterior tarsal wedge.



It will be found that with correction of the cavus the toes will straighten out. It is only occasionally that any direct attention need be paid to them, although some hammer toes will have to be taken care

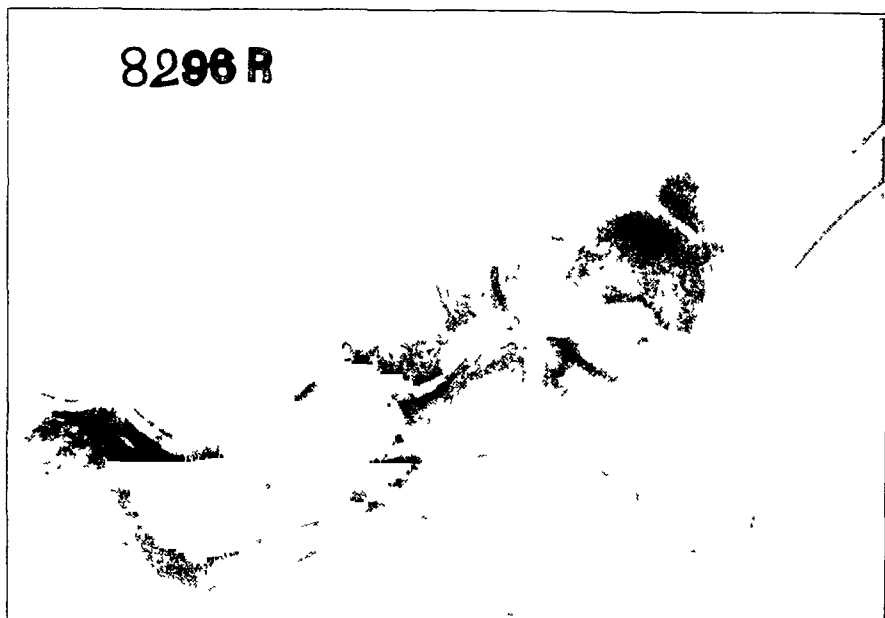


FIG. 14-A

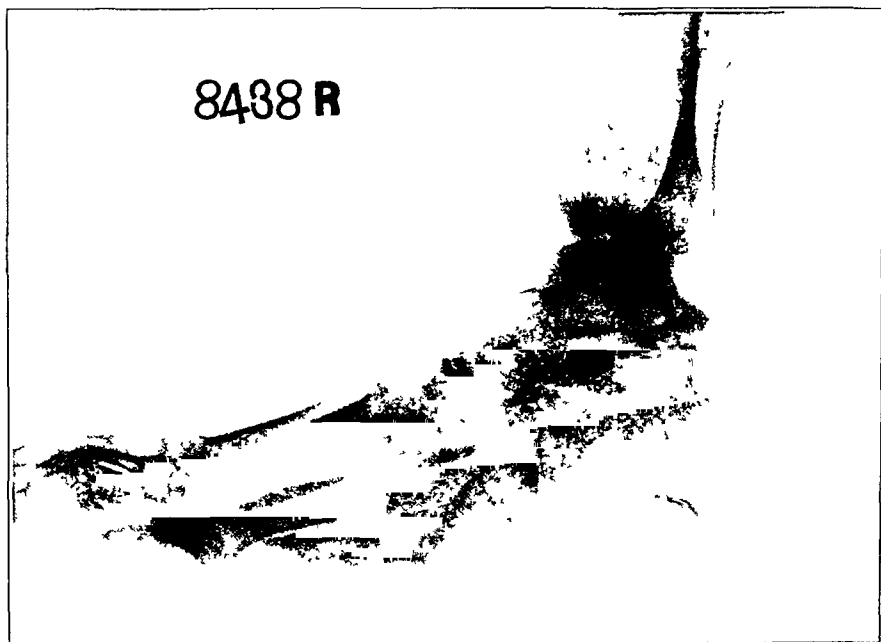


FIG. 14-B

K. T. Roentgenograms of claw-foot before and after plantar fasciotomy and anterior-wedge osteotomy.

of in the older individuals. Callosities disappear when their cause is removed, but at times the use of salicylic-acid preparations will be necessary to hurry the convalescence. The tendon transplantation described may occasionally be indicated after this osteotomy.

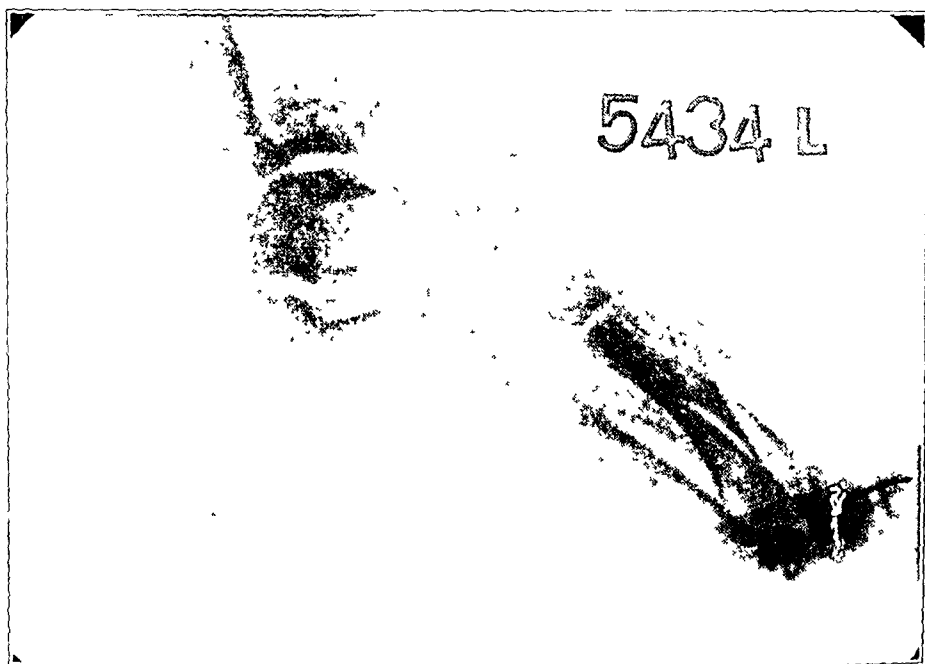


FIG. 15-A

N. R. Roentgenogram showing marked bone cavus before operation.

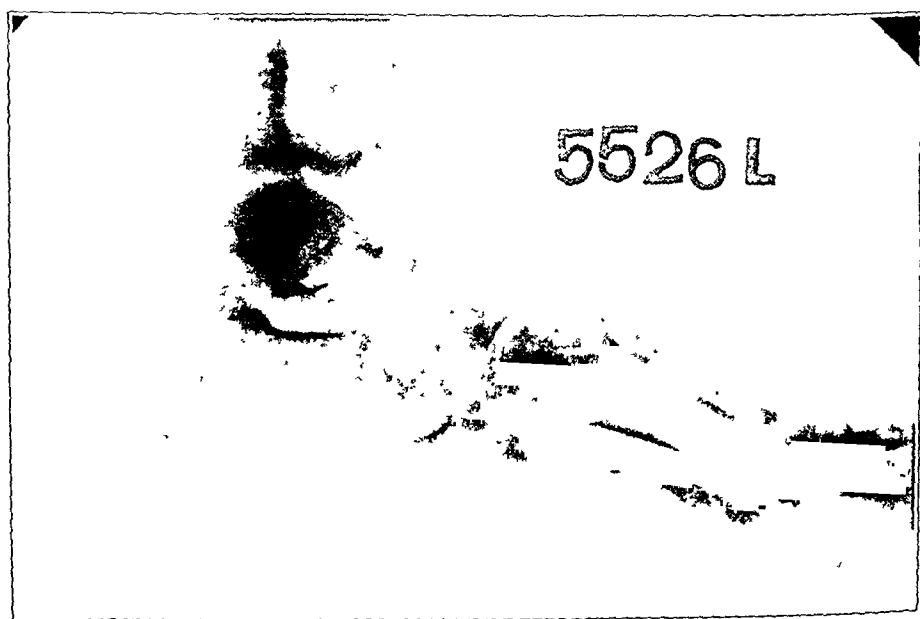


FIG. 15-B

N. R. Roentgenogram after plantar fasciotomy and anterior-wedge osteotomy.

There are some exceptional cases of claw-foot, in addition to those that have been discussed, where a good result can be obtained only by arthrodesis, and one will see very rarely an old neglected case where

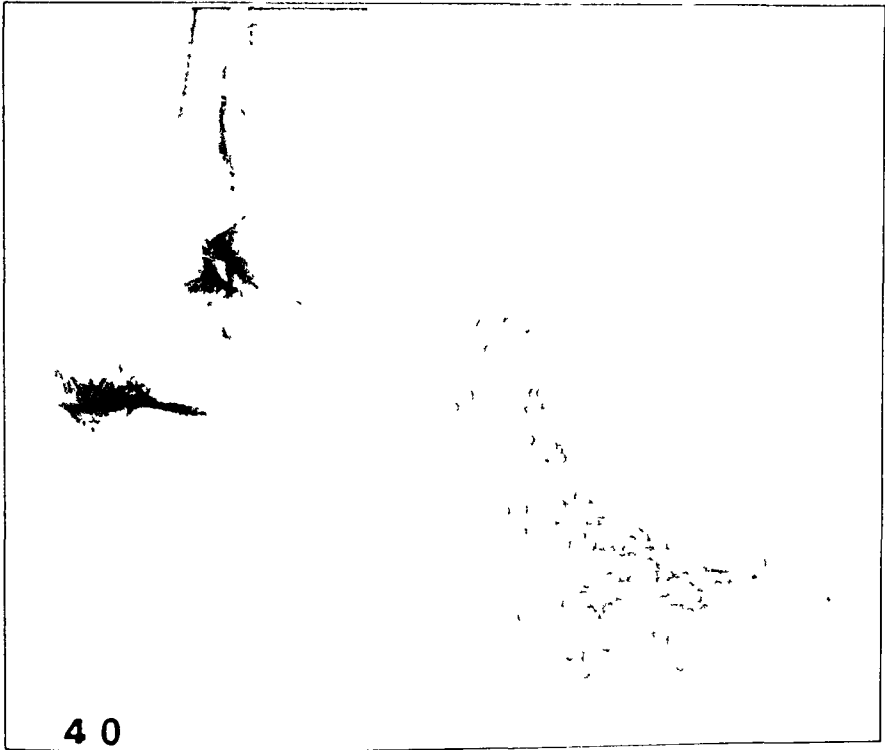


FIG 15-C

N. R. Roentgenogram taken seven years later showing functioning midtarsal joint.

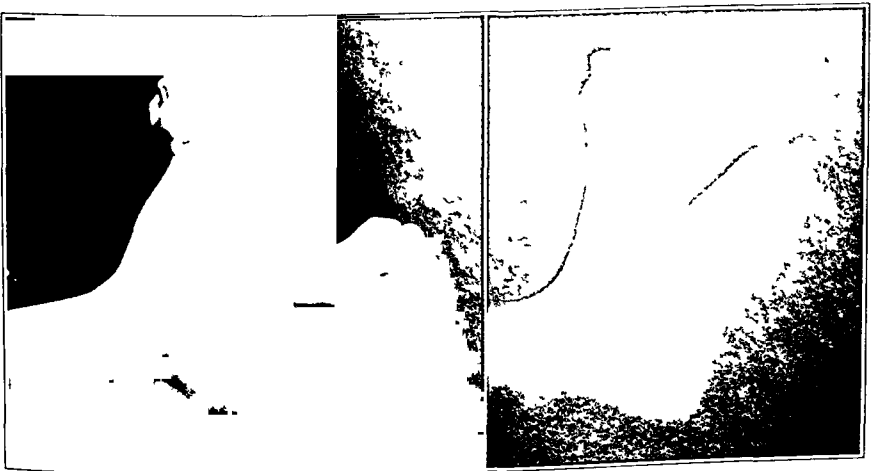


FIG. 16-A

FIG 16-B

C. A. Claw-foot before and after transplantation of the toe extensors.

amputation is the only solution. However, these cases are not common, and the more conservative measures, resulting in the retention of a function which is usually excellent, will be found sufficient in the vast majority of claw feet. A few illustrations will show the effect of the treatment advocated (Figs. 10-A to 16-B).

#### SUMMARY

1. True claw-foot is due to a lesion of the spinal cord, usually spina bifida occulta or poliomyelitis, with resulting weakness of certain muscles of the foot. It is, therefore, a symptom and not an entity.

2. By systematic treatment some cases at least can be checked and others corrected with good functional feet resulting.

3. Transplantation of the toe extensors to the cuneiform bones will aid in keeping the sole flat and preventing a progressive cavus.

4. When wedge osteotomy is necessary to overcome the cavus, an anterior tarsal wedge will save function, and correct the deformity.

# DEFORMITIES OF THE FEMUR RESULTING FROM ARRESTMENT OF GROWTH OF THE CAPITAL AND GREATER TROCHANTERIC EPIPHYSES

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The importance to the clinician of some knowledge of the physiology of bones and of other supporting tissues cannot be overemphasized. This is particularly true for the physician who limits his clinical work to the treatment of conditions which affect these structures. The longitudinal growth of bone occurs from the epiphyseal cartilages. The susceptibility of these growth centers to injury from trauma or disease, producing growth arrest and resulting in shortening of extremities and in deformities, has been adequately stressed by clinical observers and by reports of laboratory experiments (Haas, Speed and Macey, Gatewood and Mullen, Compere, and Siegling).

Occasionally, even an experienced surgeon has carried out and recommended some surgical procedure which endangers the irreplaceable growth cartilages of the bones of growing children.

Bozsán, in 1931, in a case presentation before the Clinical Society of the Hospital for Joint Diseases, recommended multiple drilling as a method of treating fracture of the neck of the femur, slipped femoral epiphysis, and Legg-Calvé-Perthes disease. He described this procedure in *The Journal of Bone and Joint Surgery* for October 1932 and again, in slightly greater detail, in the same publication in January 1934. Later in the same year, Ferguson and Howorth described a similar procedure, which they stated would be indicated for early cases. These authors emphasized the fact that the operation itself was relatively simple and that there were no immediate morbid results, such as death or serious infections. The theory of the operative procedure was to provide channels for hastening the revascularization of the femoral head. In cases of Legg-Calvé-Perthes disease these channels had to be drilled through the epiphyseal-cartilage plate, joining the capital epiphysis to the diaphysis of the neck. The fact that such drilling might result in permanent injury to growth-cartilage cells on the metaphyseal side of the capital or greater trochanteric epiphyses appears to have been overlooked.

In 1935, one of us (Compere) reported a high incidence of growth deformities resulting from fractures which involved the shaft, growth-cartilage plates, and epiphyses of a long bone. Cases have been observed in which surgeons operated well, but not wisely, in performing open re-

\* This work was made possible in part by aid from the Douglas Smith Foundation.

ductions of fractures near the growth centers of bones of small children. Some of these operations resulted in growth deformities so severe as to cause permanent disability.

Experiments were undertaken to determine just what deformities could be anticipated as a result of gross trauma to the growth center of the greater trochanter or of the capital epiphysis of the femur.

#### EXPERIMENTAL METHOD

Twenty-three puppies, approximately six weeks of age, were used in the beginning of the experiment. Most of these animals succumbed to snuffles or other kennel infections. An attempt was made to use young rabbits, but the proximal femoral epiphyses were too small to subject them to multiple drilling.

One or both of the two major growth centers of the proximal end of one femur in each of twenty-seven goats, six weeks of age, were subjected to operative trauma.

*Group I:* A portion of the cartilage plate between the epiphysis of the greater trochanter and the shaft was curetted and chips of bone were placed in the defect.

*Group II:* The epiphyseal-cartilage plate of the greater trochanter was drilled from three to six times with a rotary bit, one-sixteenth of an inch in diameter.

*Group III:* The drill was passed through the neck and into the head of the femur five or six times in various directions, perforating the growth-cartilage plate.

*Group IV:* A portion of the growth cartilage of the femoral neck was removed by curettage.

These goats were sacrificed at various intervals, the longest period being nineteen and one-half months after operation. In most of the animals a weak abductor resulted or a short-leg limp developed and persisted.

Roentgenograms of the femora of the goats were not satisfactory for purposes of measurement or of comparison.

At necropsy each femur, to-

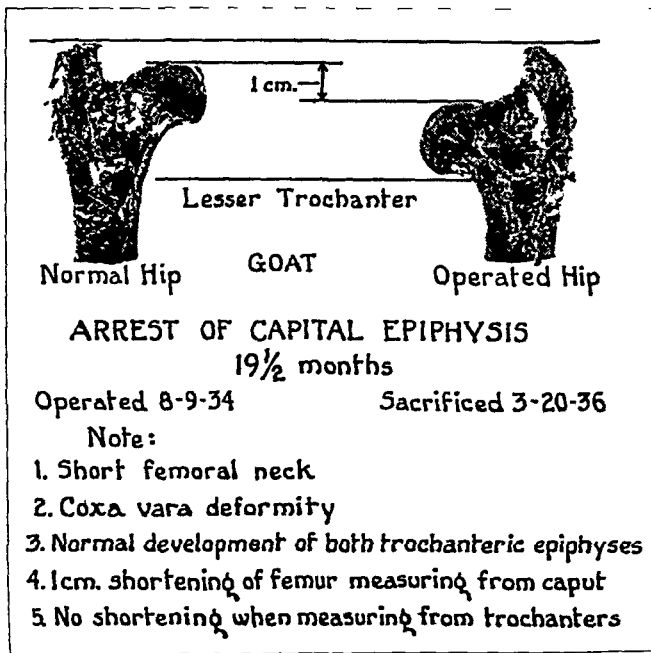


FIG. 1

gether with both trochanters, the head, and the neck, was removed and the soft tissue was stripped away. The normal femur and the operated femur of each animal were placed side by side, photographed, and x-rayed. Measurements were also taken from the apex of the head to the most distant portion of the articular surface of the medial condyle of each femur and from the tip of the greater trochanter to the articular surface of the lateral femoral condyle.

### RESULTS

In this study we are interested primarily in end results from the standpoint of growth, and measurements of the immature animals are not included. Operative trauma, whether from multiple drilling or from curettage of the growth cartilage of either the greater trochanter or the capital epiphysis, resulted in growth arrest from this center. Growth arrest following drilling did not occur as promptly as that which resulted from extensive curettage. The end results were quite comparable. When the goats were sacrificed from eighteen to nineteen months after operation, the operated hips of goats from Groups I and II, in which the growth center of the capital epiphysis had been injured, showed a characteristic deform-

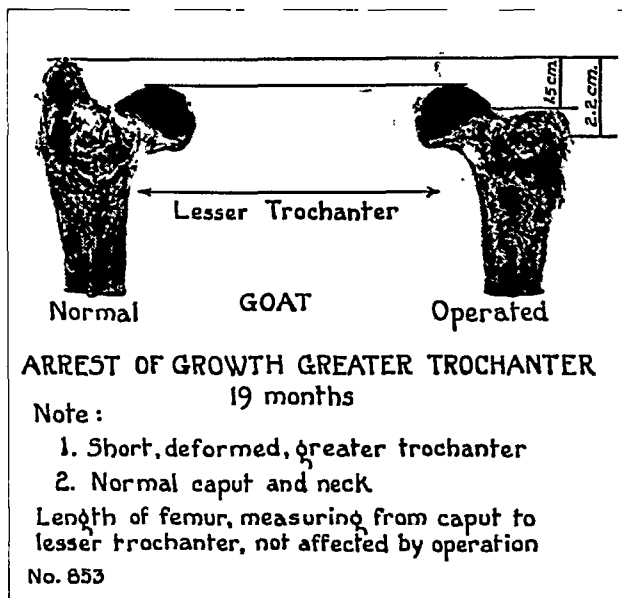


FIG. 2

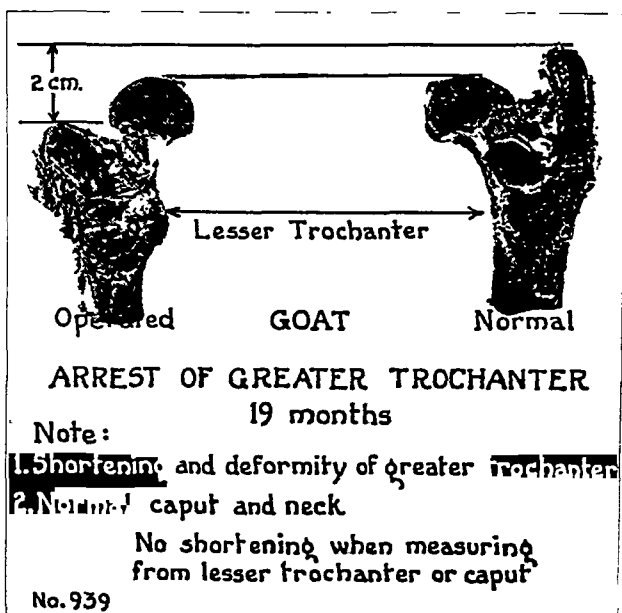


FIG. 3

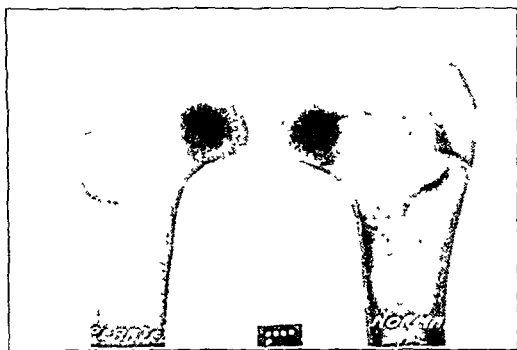


FIG. 4

Roentgenograms of the proximal end of a normal femur of a goat and of a femur eighteen months after multiple drilling through the greater trochanter. The roentgenogram of the operated femur shows the shortened, deformed trochanter. Longitudinal growth of the shaft has continued.

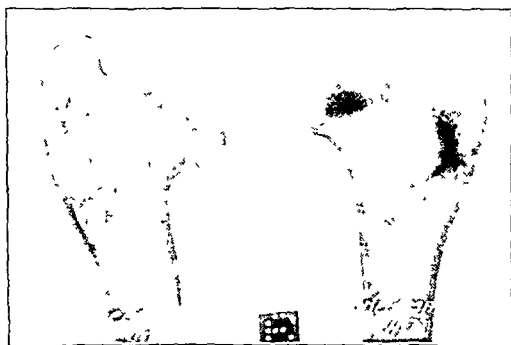


FIG. 5

Roentgenograms of the proximal end of a normal femur of a goat and of a femur eighteen months and nineteen days after multiple drilling of the neck and head. In the operated femur there is deformity, as evidenced by the irregular outline of the head, the short neck, and coxa vara. The trochanter has continued to grow.

obtained from Goat 947, nineteen months after operation (Fig. 6). The growth of the greater trochanter had been incompletely arrested on one side. This had resulted in coxa valga deformity, rotation of the shaft proximally, and an increase in the anterior femoral bow. Because of continued growth of the capital epiphysis, together with the coxa valga, the length of the femur was slightly greater than that of the unoperated leg.

The average length of the femora of the young goats (aged six to seven weeks) was ten and six-tenths centimeters. The average length of the normal femora of the adult goats (aged nineteen months) was nineteen and six-tenths centimeters. Length growth of the femora from the age of seven weeks to physical maturity was nine centimeters. The loss in length (greater trochanter to articular surface of the lateral condyle) which resulted from fusion of the epiphysis of the greater trochanter to the

ity of short femoral neck, coxa vara, and a trochanter which had grown well beyond the highest point of convexity of the femoral head (Fig. 1). There was an actual shortening of one centimeter.

Nineteen months after surgical trauma to the greater trochanter, this structure was grossly maldeveloped, and there was a definite coxa valga. No shortening of the neck or deformity of the head on the side of the operation was noted (Figs. 2 and 3).

Roentgenograms of the upper ends of the femora of goats, following growth arrest of the greater trochanter, showed the shortened trochanter with coxa valga deformity of the neck (Fig. 4). Roentgenographic changes resulting from traumatic insult to the growth cartilage of the head of the femur included a short neck, irregular contour of the head, and moderate coxa vara deformity (Fig. 5).

Deformity of the shaft of the femur, as well as of the neck, is illustrated in the print of roentgenograms of the specimens





FIG. 6

Roentgenograms of the full length of the shafts of both femora of a goat nineteen months after multiple drilling of one greater trochanter. This illustrates the coxa valga, the deformity of the greater trochanter, and the moderate torsion of the proximal end of the femur. Approximately two millimeters of greater length of the femur of the operated side may be explained on the basis of the coxa valga. A question of possible growth stimulation, resulting from the hyperaemia associated with the trauma of operation on the greater trochanter, must also be considered.

shaft of the seven-weeks-old goats averaged slightly more than two centimeters. This represents an actual loss of the total trochanteric-condylar length growth of 22 per cent.

The average shortening which resulted from fusion of the capital epiphysis, measured from the apex of this epiphysis to the knee joint, was one centimeter, or a total loss of growth of the shaft of 11 per cent.

If a comparable degree of shortening results within six years following multiple drilling of the neck of the femur of a child afflicted with Legg-Calvé-Perthes disease, the disability will not be inconsequential. The end result of such surgery must be sought ten or twelve years after infliction of the specific trauma.

#### DISCUSSION

The contention of Bozsán, Ferguson and Howorth, and others that drilling the neck of the femur, with extension of the drill into the femoral

head, may hasten revascularization may be substantiated by the evidence which they present. When this procedure is proposed for treatment of fractures of the neck of the femur, we are not prepared to disagree. Drilling of the neck of the femur to promote healing after slipping of the femoral epiphysis may be justified if it does promote an earlier union between the capital epiphysis and the metaphysis of the neck. The average patient suffering from epiphyseolysis is at least approaching the age of puberty and skeletal maturity. Furthermore, most of these patients do not recover completely, regardless of the type of treatment, until fusion and growth arrest take place.

The patient with Legg-Calvé-Perthes disease, however, presents a very different problem. Granted that the pathology includes aseptic necrosis of the capital femoral epiphysis and that the process of replacement by creeping substitution is exceedingly tedious, requiring two or more years, nevertheless any procedure which may produce growth disturbance in the femur of a young child should be considered radical and ill advised. The average age at onset of Legg-Calvé-Perthes disease is approximately seven years. At this age most of the length growth of the bones has not yet taken place. The risk of a deformity of the hip should be avoided by the surgeon who is charged with the care of a patient with a self-limiting disease.

#### CONCLUSIONS

1. Surgical trauma to the greater trochanter of the hip of a growing animal, produced by multiple drilling or curettage of the epiphyseal-cartilage plate, results in growth arrest with deformity and shortening of the greater trochanter. There is an associated coxa valga of the neck of the femur.

2. Surgical trauma to the epiphyseal-cartilage plate of the head of the femur by multiple drilling or by curettage uniformly results in growth arrest, which produces a short femoral neck, an irregular contour of the head of the femur, coxa vara, and a functional shortening of the shaft of the femur, as measured from the articular surface of the head to the articular surface of the knee.

3. The operation of drilling the necks of the femora of young children for the purpose of hastening revascularization of the head in cases of Legg-Calvé-Perthes disease is a very questionable procedure.

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# TREATMENT OF OSTEOGENIC SARCOMA\*

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The author's first paper on this subject<sup>1</sup> offered evidence that early amputation is not the best treatment of osteogenic sarcoma, and recommended delay of amputation with use of radiation, or excision, or both before amputation. The present paper gives further indications that early amputation is not the best treatment, and analyzes cases seen within two months of onset of symptoms to show that lack of haste in amputating improved results.

## DEFINITIONS

Early amputation is defined as amputation before the seventh calendar month after onset of symptoms.

Survivors are defined as patients alive more than five years after the last treatment of the local lesion with no evidence of tumor at the last report.

## STATISTICAL STUDY

The cases studied are the first 400 cases of undisputed osteogenic sarcoma which had the necessary data for tabulation, recorded in the Registry of Bone Sarcoma of the American College of Surgeons.

The favorable results obtained at various clinics or hospitals registering ten or more cases included in this series appeared to be proportionate to their lack of haste in amputating (Table I). The higher percentage of survivors was obtained at the clinics having the higher percentage of late amputations.

TABLE I

RESULTS OF TREATMENT OBTAINED IN 400 CASES OF BONE SARCOMA BY HOSPITALS AND CLINICS REGISTERING TEN OR MORE CASES, WITH NUMBER AND PERCENTAGE OF LATE AMPUTATIONS

Clinic	Cases	Survivors		Late Amputations	
		No.	Per Cent.	No.	Per Cent.
A.....	13	5	38.4	8	61.5
B.....	30	6	20.0	11	36.7
C.....	69	10	14.5	19	27.5
D.....	12	1	8.3	3	25.0
E.....	12	1	8.3	2	16.7
Other Clinics.....	264	40	15.2	81	30.7
Total.....	400	63	15.8	124	31.0

\* Presented at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Boston, Massachusetts, on January 24, 1940.

TABLE II  
TREATMENT AND RESULTS OF 400 CASES OF BONE SARCOMA  
CLASSIFIED ACCORDING TO SEX

Treatment	Male				Female			
	Cases		Survivors		Cases		Survivors	
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent.
Early amputation	94	37 3	8	8 5	40	27 0	3	7 5
No amputation	80	31 7	9	11 3	62	41 9	7	11 3
Late amputation	78	31 0	22	28 2	46	31 1	14	30 4
Total	252	100 0	39	15 5	148	100 0	24	16 2

Males and females had similar survival rates with each of the various types of treatment indicating that the disease was equally malignant in the two sexes. Females were treated without amputation more often, and by early amputation less often than the males. This did not cause the females to have the higher death rate that would be expected if early amputation were the best treatment (Table II).

Early amputation was used more frequently in cases registered in later years as compared to the earlier years. The increase in early amputations was not accompanied by an increase in survivors. The campaign for earlier amputations resulted in an increase in very early amputations

TABLE III  
RESULTS OF TREATMENT OF 400 CASES CLASSIFIED ACCORDING TO PERIOD OF  
REGISTRATION OF CASES WITH THE REGISTRY OF BONE SARCOMA

Treatment	First 165 Cases				Next 135 Cases				Last 100 Cases			
	Cases		Survivors		Cases		Survivors		Cases		Survivors	
	No.	Per Cent	No.	Per Cent.	No.	Per Cent	No.	Per Cent	No.	Per Cent.	No.	Per Cent.
Amputation at 1 to 3 months	17	10 3	1	5 9	24	17 8	1	4 2	20	20 0	1	5 0
Amputation at 4 to 6 months	26	15 8	4	15 4	27	20 0	4	14 8	20	20 0	0	0 0
Total early amputations	43	26 1	5	11 6	51	37 8	5	9 8	40	40 0	1	2 5
No amputations	69	41 8	8	11 6	43	31 8	4	9 3	30	30 0	4	13 3
Late amputations	53	32 1	15	28 3	41	30 4	13	31 7	30	30 0	8	26 7
Total	165	100 0	28	17 0	135	100 0	22	16 3	100	100 0	13	13 0



FIG. 1

Three examples of osteogenic sarcoma of the fibula treated by amputation in the second month after onset of symptoms. All patients died. Registry numbers: 707, 637, 1241.

among the early amputations in the later periods of the Registry. Early amputations increased approximately 50 per cent., very early amputations approximately 100 per cent., but survivors of early amputation decreased from 11.6 to 2.5 per cent. Is very early amputation deadly? (Table III.)

CASES SEEN WITHIN TWO MONTHS OF ONSET OF SYMPTOMS

Some cases seen within two months of onset of symptoms were becoming rapidly worse, and clinically could properly be judged wildly malignant. Such patients were not treated by early amputation; they regularly received radiation only, or no treatment at all.

The cases treated by amputation within two months of onset of symptoms included all varieties of early osteogenic sarcoma. Most of them warranted the hope that amputation was being performed early enough to save the patient if that hope ever could be warranted. The accompanying illustrations depict some of these cases; each patient had amputation within two months of onset of symptoms, and subsequently died. Only one out of thirty-eight patients so treated survived. Similar cases, seen equally early, had other treatment before amputation, and

TABLE IV

RESULTS OF AMPUTATION ON PATIENTS ELEVEN TO TWENTY YEARS OF AGE  
SEEN WITHIN TWO MONTHS OF ONSET OF SYMPTOMS

Treatment	Cases		Survivors	
	No.	Per Cent.	No.	Per Cent.
Amputation in 1 or 2 months . . . . .	29	51 8	1	3.4
Amputation in 3 to 6 months . . . . .	20	35 7	4	20 0
Amputation after 6 months . . . . .	7	12 5	2	28.5
Total . . . . .	56	100 0	7	12 5



FIG. 2

Three examples of osteogenic sarcoma of the tibia treated by amputation in the first or second month after onset of symptoms. All patients died. Registry numbers: 683; 474; 1228.

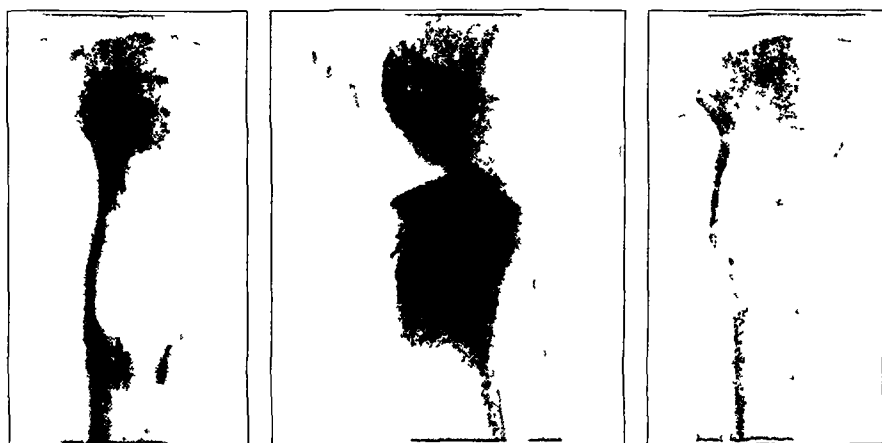


FIG. 3

Three examples of osteogenic sarcoma of the tibia treated by amputation in the first or second month after onset of symptoms. All patients died. Registry numbers: 1239, 1291, 1326.

many patients survived. Such results, presented in Tables IV, V, and VI, condemn very early amputation.

Of 107 patients seen within two months of onset of symptoms twenty had no treatment, radiation only, or excision only. Five others, of whom two survived, were treated by excision and radiation without amputation. These survivors were cases of possibly low malignancy, and are, therefore, dismissed from further consideration. It might be pointed out, however, that in four other cases of possibly low malignancy, seen early, the patients were treated by early amputation, and died.

There remain eighty-two cases seen within two months of onset of symptoms and treated by amputation (Table VI).

TABLE V

RESULTS OF AMPUTATION FOR SARCOMA OF THE DISTAL FEMUR AND PROXIMAL TIBIA  
IN CASES SEEN WITHIN TWO MONTHS OF ONSET OF SYMPTOMS

Treatment	Distal Femur				Proximal Tibia			
	Cases		Survivors		Cases		Survivors	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Amputation in 1 or 2 months . .	16	42 1	1	6 2	11	50 0	0	0 0
Amputation in 3 to 6 months .	19	50 0	3	15 8	7	31 8	1	14 3
Amputation after 6 months	3	7 9	0	0 0	4	18 2	1	25 0
Total . .	38	100 0	4	10 5	22	100 0	2	9 1

Seventeen of the eighty-two cases seen very early were judged, histologically, to be of unusually high malignancy, but this does not explain the poor results of very early amputation, as the cases of unusually high malignancy formed only 13 per cent. of those having amputation in two months, 25 per cent. of those having amputation in three to six months, and 30 per cent. of those with late amputation. The only one of these patients who survived had radiation preceding amputation three months after onset.

The age period from eleven to twenty years produced the only survivors after early amputation, but even in this favorable age period the earlier amputations gave the poorer results (Table IV).

The distal portion of the femur and the proximal portion of the tibia were the sites which produced the only survivors after early amputation,

TABLE VI

EFFECT OF RADIATION ON RESULTS OF AMPUTATION IN EIGHTY-TWO CASES  
SEEN WITHIN TWO MONTHS OF ONSET OF SYMPTOMS

Time of Amputations	Total Amputations				Amputation with No Radiation				Amputation after Radiation			
	Cases		Survivors		Cases		Survivors		Cases		Survivors	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
1 or 2 months	38	46 3	1	2 6	35	63 6	1	2 8	3	11 1	0	0 0
3 to 6 months	31	37 8	4	12 9	16	29 1	1	6 2	15	55 6	3	20 0
After 6 months	13	15 9	3	23 1	4	7 3	0	0 0	9	33 3	3	33 3
Total . . . . .	82	100 0	8	9 8	55	100 0	2	3 6	27	100 0	6	22.2



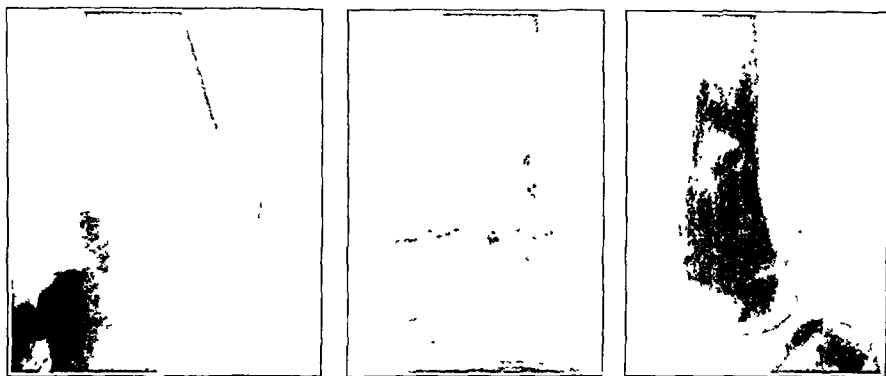


FIG. 4

Three examples of osteogenic sarcoma of the femur treated by amputation in the first month after onset of symptoms. All patients died. Registry numbers: 1329; 761; 1319.

but even at these favorable sites the earlier amputations gave the poorer results (Table V).

Amputation without previous radiation yielded poor results in the cases seen early after onset of symptoms (Table VI).

Thus, in the eighty-two cases seen within two months of onset of symptoms, and treated by amputation, neither age, site, variation in treatment, nor degree of malignancy estimated histologically explains the fact that the earlier amputations had the poorer results.

In no case did the patient survive amputation in the first month after onset of symptoms.

In no case did the patient survive early amputation if aged one to ten or over twenty.

No patient survived early amputation if the lesion was not at the distal portion of the femur or the proximal portion of the tibia.

The advocates of early amputation in osteogenic sarcoma of an extremity may persist in amputating as early as the third month after onset of symptoms, if the patient is between eleven and twenty years of age, and has a lesion at the distal portion of the femur or the proximal portion of the tibia. However, in any other instance they can offer no tangible hope of success, and should, therefore, agree to the delay of amputation which does offer hope of success.

The best treatment to be used while amputation is delayed is still undetermined, but the following are recommended, with the choice depending upon the surgical feasibility of the operative procedures:

1. Radiation.
2. Excision and radiation.
3. Excision and implantation of bone graft or chips, with or without radiation.

If excision is used, it should be repeated if recurrence becomes evident before amputation is performed. The interval between the last

excision and amputation should not be less than three weeks, and probably should not exceed two months, if benefit is to be derived from combining the two treatments.

The optimum time for amputation is a quiet period in the course of the disease,—a period when the patient is not losing weight; when the phosphatase content of the blood is not elevated; when there has been no sudden or marked increase of pain or swelling for two months; and when there has been no recent marked increase of mass or destruction demonstrable roentgenographically. Such periods occur with some frequency after the first six months of osteogenic sarcoma, and earlier in the course of the disease may be produced with the potent aid of radiation.

Whatever one may select as the treatment of choice, it can be definitely stated that very early amputation in osteogenic sarcoma of an extremity does not appear to be the best treatment.

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# SURGICAL TREATMENT OF OSTEO-ARTHRITIS OF THE HIP JOINT

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This investigation was carried out in an endeavor to evaluate the merits of the more modern methods of surgical treatment of osteo-arthritis of the hip joint. Between January 1, 1926, and December 31, 1937, inclusive, seventy-seven patients suffering from osteo-arthritis of the hip joint were subjected to various surgical procedures at The Mayo Clinic, and the present paper is based on the clinical, laboratory, roentgenographic, and surgical findings in these cases.

There is no one etiological agent which is common or equally active in all cases. The pathological features are rather the result of the long-continued and united action of a multiplicity of small factors, each of which contributes its quota to the final whole.

The average age at onset among men, as evidenced by our cases, was fifty-two and seven-tenths years and that among women was forty-seven and five-tenths years. Men tended to be affected two and a half times as commonly as women. There seemed to be a definite relationship between obesity and the onset of osteo-arthritis. The presence of coxa vara, coxa valga, Perthes' disease, loose bodies, or subluxation as described by Wiberg, may predispose to the onset of osteo-arthritis among persons in the younger age groups, as demonstrated by sixteen of our cases.

## TREATMENT

The case of the person suffering from severe osteo-arthritis (Fig. 1), while not so tragic as that of an individual crippled by rheumatoid arthritis, is nevertheless a serious one. Here we have a man, otherwise physically capable and in robust health, who is rendered useless and frequently becomes a hanger-on of charitable associations, on which he is dependent for his daily bread, all because of a painful hip joint. There are also the patients, who, disgruntled and disappointed in the benefits to be had at the hands of the orthodox members of the medical profession, crowd the consulting rooms of unorthodox practitioners. Although it is manifestly impossible to repair an architecturally distorted joint, surgical treatment does offer hope of alleviation. We know that fixation of the joint will give relief from pain, but, from the point of view of function, this is as radical a procedure as amputation performed for the cure of tumor.

It would be of great help in the treatment of osteo-arthritis if it were possible to identify certain stages of this disease for which one form of



FIG. 1

Osteo-arthritis of both hips.

treatment or another would prove specific. Unfortunately, we have not been able to state definitely on examination of the roentgenographic findings that one case would respond better to manipulation or that another was more suited to a bone-drilling operation. However, we have tried to divide our cases arbitrarily into three fairly well-defined groups, for which certain forms of treatment have been found to be suitable.

In Group A we include cases in the earlier stages of the disease, in which rarefaction or condensation is present in the femoral head and the superior border of the acetabulum, but in which no excessive hypertrophic changes have appeared. The use of manipulative measures alone or associated with the bone-drilling operation has resulted in an appreciable improvement in the condition of a number of these patients.

Group B consists of those cases in which hypertrophic changes are present on the acetabular margins and surrounding the head of the femur, so that motion is markedly restricted in all directions. Cheilotomy or acetabuloplasty appears to be the method indicated, although, in a few cases, reconstructive measures of the Whitman or Colonna type must be considered also.

Under Group C we place those cases in which the principal complaint is pain, for which relief has not been obtained by the usual measures of physical therapy or rest. These patients usually have considerable distortion of the normal contours of the femoral head and acetabulum, and

for them we advise arthrodesis. However, even in this group we shall have to modify our views if experience proves that the more recently devised method of Smith-Petersen<sup>6</sup>, which entails the use of vitallium caps, is a better form of therapy.

In an effort to assess the benefits to be derived from the various methods of surgical treatment, we have divided our group of seventy-seven patients into subdivisions, depending on the methods used in their treatment.

### *Manipulation*

Manipulative manoeuvres to the fullest extent of motion short of using extremes of force were carried out in eleven cases, with the objective of breaking down capsule and muscle adhesions. In those cases in which muscle spasm had produced adduction and flexion deformities, manipulation was supplemented by subsequent fixation in extension and abduction by plaster-of-Paris spicas, extending from the costal margin to the knee or toes on the affected side and to the lower third of the thigh on the sound side. While adduction and flexion could be corrected to a great degree by manipulation, casts, and, in some cases, by subsequent traction, external rotation usually defied all our efforts at correction. Fixation in plaster-of-Paris was continued over a period which varied from two weeks to two months, depending on the degree of deformity. During this period the patients could move around on crutches. After removal of the cast, physical therapeutic measures materially increased the rapidity of recovery of active movements.

Two patients were treated by manipulation and physical therapy. Of these, one, into whose joint thirty cubic centimeters of iodoform emulsion had been injected also, reported eight years later that his condition was unimproved, but no worse. The other died fourteen months after treatment without having reported on the condition of his hip joint in the interval. In nine cases the hip joints were manipulated under intravenous or spinal anaesthesia and fixed in casts as described.

Reports of the patients' condition were received from three months to eight years later. Of the entire group of eleven patients, four reported an improvement in their condition, but in only one case was this marked. Four patients stated that their symptoms were unrelieved, and an additional one claimed that his condition was worse than before the manipulation. One patient was found to have died in the interval, and from the remaining patient no reply was received. Of the nine patients whose condition was known, 44 per cent. reported improvement.

### *Bone-Drilling*

The simplicity of the bone-drilling operation suggested by MacKenzie of Australia recommended it to our consideration. The procedure consists in drilling one large hole or a series of smaller holes from the lateral aspect of the greater trochanter through the neck into the head. The

operation may be done under local infiltration or spinal anaesthesia under roentgenoscopic control or by means of wire guides, the exact location of which has been checked by anteroposterior and lateral roentgenograms. The objective of the operation is the revascularization of the femoral head and neck; the operation itself is based on the relief from pain which followed the fracture of the neck of the femur of one of MacKenzie's patients, who had suffered from very severe and painful osteo-arthritis of that hip. When union occurred, relief of pain was so striking that it led MacKenzie to ponder on the cause and resulted in his suggesting the bone-drilling operation as a form of treatment in similar cases.

This operation was done in twenty-eight cases. In sixteen, a single drill opening—one-fourth, three-eighths, or one-half an inch (0.63, 0.93, and 2.5 centimeters) in diameter—was made, whereas in twelve cases, multiple drillings were performed. In one case, in addition to drilling, the fascia lata was cut in a manner similar to that advised by Ober in treating sciatica; in two cases, arthrotomy and drilling were carried out; in two cases, the bone was drilled, and, in addition, the capsule was sectioned anteriorly. In the three cases in which capsulotomy or section of the fascia lata was performed, the hip was manipulated also. In only two cases were both hips operated on at the same time. So far as we could ascertain, the slight modifications had but little effect on the end results.

In the postoperative care of these patients, complete rest for from three to five days with heat and sedatives was given if necessary. During this period, further relief was afforded to two patients by the application of Buck's extension. Usually about the fourth day, gentle active movements or passive movements by means of a knee sling were begun. After the sixth day, in most cases, the patient was encouraged to sit up for a short period twice daily, after which crutches and a walker were provided, and the patient was urged to walk.

Twenty-five patients replied to our follow-up inquiry. The interval between the operation and the inquiry varied from two months to three years. Of the three patients who did not reply, one subsequently was found to have died about two years after operation, but we were unable to obtain any record of the state of her hip joint. Of the twenty-five patients who replied, nine were improved, and, of these nine, four were remarkably benefited. Eight were worse after the operation, and five claimed that their postoperative state was not different from their condition previous to surgical treatment. Three patients stated that they were relieved of pain, but that functional ability was not improved. Taken at its lowest value, nine out of twenty-five, or 36 per cent., were helped by drilling the hip, and 16 per cent. were markedly relieved.

### *Cheilotomy of the Femoral Head*

The method used in this procedure was that described by Sir Robert Jones, the heads being reduced in size by from two-thirds to four-fifths. This operation was done in four cases, in each of which the acetabular

marginal excrescences were left undisturbed. Extension caliper splints were applied for from ten to fourteen days, and prolonged physical therapy was recommended following operation.

Were it possible to follow these cases for several years, one feels that the late reports would be, to say the least, disappointing. Probably it is best to consider this a more or less useless operation.

### *Cheilotomy of the Femoral Head and Acetabulum*

This operation was carried out in six cases. The Smith-Petersen approach<sup>5</sup> was used in four cases, while a lateral incision was used in two. Osteophytes were removed from the head and from the acetabular margins. In five cases the hip joint was subsequently fixed in a double hip spica for from eleven to forty-two days; in one of the cases the position of the joint was maintained by Buck's extension without plaster fixation. Following removal of the cast, movements were instituted by means of the arthroplasty splint and later carried out voluntarily. The use of crutches and the walker followed. Physical therapy was employed throughout.

Three patients, at two, three, and three and a half years, reported very good results with increased range of movement, freedom from pain, and sufficient stability to allow them to discard all support. The fourth patient wrote that his condition was only fair, but was improving at the end of six months. The fifth stated that he had spells of severe pain at the end of one year. This statement conveyed the impression that he had gotten along moderately well in the interval. The sixth patient, four years after operation, reported that he was only working for his keep in a lodging house. From this survey, we concluded that 50 per cent. were very definitely benefited, and that the condition of the remaining 50 per cent. was probably fair to poor.

### *Cheilotomy and Bone-Drilling*

In three cases, in addition to the removal of the osteophytes of the femoral head and acetabular margins, the ilium was drilled in the region just superior to the acetabular roof. The osteophytes on the inferior acetabular rim were not disturbed. In two cases, these hypertrophic growths were one inch (2.5 centimeters) thick at their bases and overhung the head like a canopy. These patients were urged to use a knee sling after four days' rest and to move the hip by the end of the second week.

One patient did not reply to our inquiry. The second, two years after operation, said that he was unable to walk on account of pain. The third, however, two years and three months after operation, reported that the pain had gone and that improvement had been steady. The other hip, however, was showing signs of similar but progressive disability. Thus, there was improvement in the condition of the two patients who were traced.

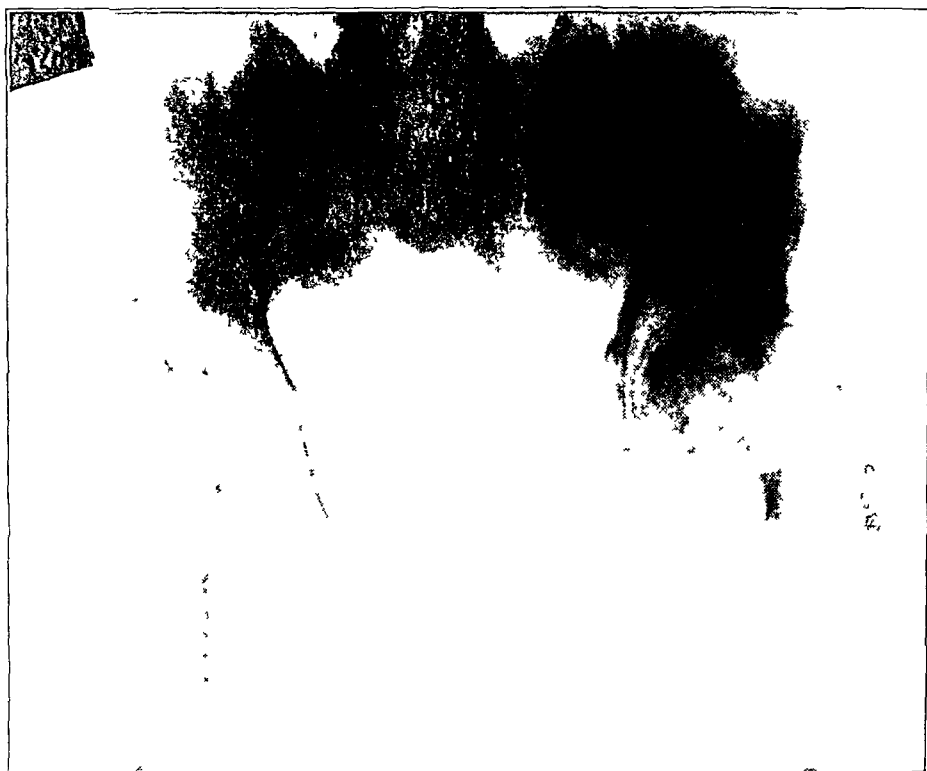


FIG. 2

Fifteen months after Whitman reconstruction operation.

### *Subtrochanteric Osteotomy*

Only one patient was treated by this method, and he stated that four months after operation he was unable to work and could not walk without crutches.

### *Acetabuloplasty*

This was performed in five cases after the method described by Smith-Petersen<sup>9</sup> in 1936. The anterior lip was removed, but care was taken to preserve the superior border in order to maintain joint stability. The hypertrophic excrescences of the acetabular margins were also removed. Passive movement was begun within a few days, and the patients were allowed to sit up by the tenth day. By the twelfth to the twenty-first day after operation, they were encouraged to attempt walking with the aid of crutches or a walker. Heat, massage, and diathermy were used as adjuvant measures in all the cases.

Of the five patients treated, one reported at the end of eight months that his condition was very much worse. The report submitted by a second patient, nine months after operation, was most encouraging. He claimed a "wonderful improvement", but he still used a cane. Two months after operation, the third patient reported that he was feeling much improved, and that the range of movement of his hip was increased.



A fourth patient admitted some slight improvement after fourteen months, but he stated that he continued to experience some pain and found it impossible to tie his shoe laces or to work. The last patient, seventeen months after operation, was able to tie his shoe laces and was conscious of a distinct improvement in the mobility of his hip.

Thus, we found that of five patients who were subjected to acetabuloplasty, the condition of four, or 80 per cent., was improved.

### *Reconstruction Operations*

Of the thirteen patients treated in this manner, twelve were subjected to the reconstruction operation popularized by Whitman (Fig. 2), and one had the Colonna type of reconstruction. From these patients, reports were received at intervals subsequent to the operative procedure and six, on their own showing, were found to have been benefited, although one of these had a relapse after three and a half years. Five were not improved (Whitman operation in four cases, Colonna operation in one), while two were definitely worse. These reconstruction operations have a definite place in the repertoire of the orthopaedic surgeon, but success depends, as it does in so many orthopaedic conditions, on the careful selection by the surgeon of the right type of operation and case.

### *Arthrodesis*

The intra-articular method was employed in two cases, while in four an extra-articular arthrodesis, using an iliac graft, was performed. Spinal anaesthesia was employed routinely. Postoperative fixation in a double hip spica has, in our experience, proved itself to be the best method of immobilization and was used in all cases. The patient can be turned painlessly with the minimum of trouble, and nursing measures are more easily carried out. While the possibility of bed sores is greatly reduced, if they should occur, lights and medicaments can be applied with ease. If necessary, the patient even can be slung up by one leg to an overhead bar in such a manner that all pressure can be removed from the sore and yet the security of the immobilization is not impaired. The cast is changed at the end of from one to two months; the stitches are removed and a lighter, and occasionally a single, hip spica is applied. This is left on until ankylosis occurs. If economic necessity demands it, the patient can be sent home in a cast with safety. One of our patients went home thus at the end of six weeks. As a rule, under normal conditions, bony union has occurred by the end of from six to nine months, but in osteo-arthritis it must be acknowledged that bony union does not occur readily and in some cases may never take place. When this is the case, union by fibrous tissue is the rule, and, where this is firm, a very satisfactory union may result.

In the first case, follow-up revealed that the pain had disappeared. In the second, a postencephalitic Parkinson's syndrome had developed, and, as a result, we were unable to assess accurately, two and a half years

later, the peculiar ever-changing symptoms of which the patient complained. The third, fourth, and fifth patients—one and one-half, four and one-half, and six and one-half years after operation; respectively—were free from pain, well, and, in two cases, at work. The patient in the third case was unemployed, but had had a good result. In the sixth case, the patient reported three years and nine months later that he had no pain and was able to walk five or six miles daily. This is one of those anomalous cases of arthrodesis in which, instead of ankylosis, motion results. The patient could flex his hip to 40 degrees. Function was excellent, and he was very well pleased with the end result. Roentgenographic examination demonstrated that the bone graft had formed a shelf against which the greater trochanter rested. We believe that it is quite in order to exclude the second patient from our assessment of results, because of the nature of his subsequent malady, which made his subjective symptoms of doubtful value. Thus, out of five cases, we had five good results. Even if from the technical viewpoint arthrodesis failed in one case, the ultimate end result was even better. The percentage of good results was 100, or at its lowest estimation, 80.\*

### RÉSUMÉ

In the seventy-seven cases of osteo-arthritis of the hip joint which have been reviewed, men predominated over the opposite sex in the proportion of fifty-five to twenty-two. The influence of severe trauma was not an outstanding feature. Forty-nine patients had suffered no initial injury, and from only twenty-eight was a definite history of trauma elicited.

From the point of view of therapy, undoubtedly, arthrodesis as performed by us has given the best results, but, while this is a procedure which is readily accepted in Europe, in America we have difficulty in convincing our patients of the benefits to be derived from a stiff hip. The average patient has a horror of an immobile joint and will refuse to consider an operation devised to produce this end, even when the diseased articulation is to all intents and purposes already stiff.

Of the other procedures, each has its place in well-selected cases. Drilling, combined with manipulative measures and followed by active movements, aided by physical therapeutic agents, has given good results in many cases. The more recent work of Smith-Petersen<sup>6</sup> with vitallium caps in arthroplasty of the hip joint bids fair to change our views on this operation, but, until further experience has been gained, the procedure is still *sub judice*.

Acetabuloplasty and extensive cheilotomy do give excellent results in some cases.

\* It is difficult to be dogmatic in our opinions regarding this group, since we are not certain that ankylosis was obtained in all cases. The replies to our follow-up letters indicated that the patients had obtained marked clinical benefit, but, as we were not able to obtain roentgenograms demonstrating the late end results, our opinions are deductive, not factual.

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## ANTERIOR TIBIAL TENDON TRANSPOSITION IN RECURRENT CONGENITAL CLUB-FOOT

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Conservatism in the treatment of congenital club-foot is well recognized. Brockman, in his monograph on the condition, states that only 50.6 per cent. required no further treatment after adequate conservative care. Kite has practically standardized the conservative treatment. He states that 90 per cent. of all club feet can be corrected by the wedge-cast method. In some cases, however, the deformity does recur or resist conservative methods of correction. The following is an end-result study of the transposition of the anterior tibial muscle tendon insertion in recurrent club-foot.

Of the three components in congenital club-foot,—adduction of the forefoot at the talonavicular joint, inversion, and the equinus of the forefoot as well as of the os calcis—inversion of the whole foot, but especially of the calcaneum, is the most important. Without complete correction of the inversion, correction of the deformity as a whole cannot be maintained. Residual metatarsus adductus is frequent after correction by any method. If the forefoot adduction is completely corrected, the inversion of the os calcis will be corrected in most instances.

In the cases here reported, recurrence of deformity occurred in spite of vigorous conservative treatment by manipulation, casts, club-foot braces, and thirty-six operations including: arthrodesis (4), decancellation of calcaneum (3), Hoke's (1), Ober's (2), Brockman's (3), osteotomy of talus (1), Achilles tenotomy (16), fasciotomy (4), and capsulotomy (2). Forceful wrenchings, resulting in stiffening of the tarsal joints, had previously been done on at least half.

On examination it was found that when active dorsiflexion of the foot was attempted the foot was supinated. The anterior tibial tendon, inserted at the first cuneiform bone and base of first metatarsal, pulled the whole foot into inversion, and exaggerated the inversion of the os calcis. This occurred with each step.

In every instance the strength of the peroneal muscles was not sufficient to evert or pronate the foot actively. In no patient had the inversion of the os calcis been completely corrected, and some degree of deformity in each component had recurred.

The average age of the patients was six and one-half years. Three were in their third year, and two in their sixteenth.

This operation consists of transferring the anterior tibial tendon insertion to the proximal end of the fifth metatarsal. An incision about

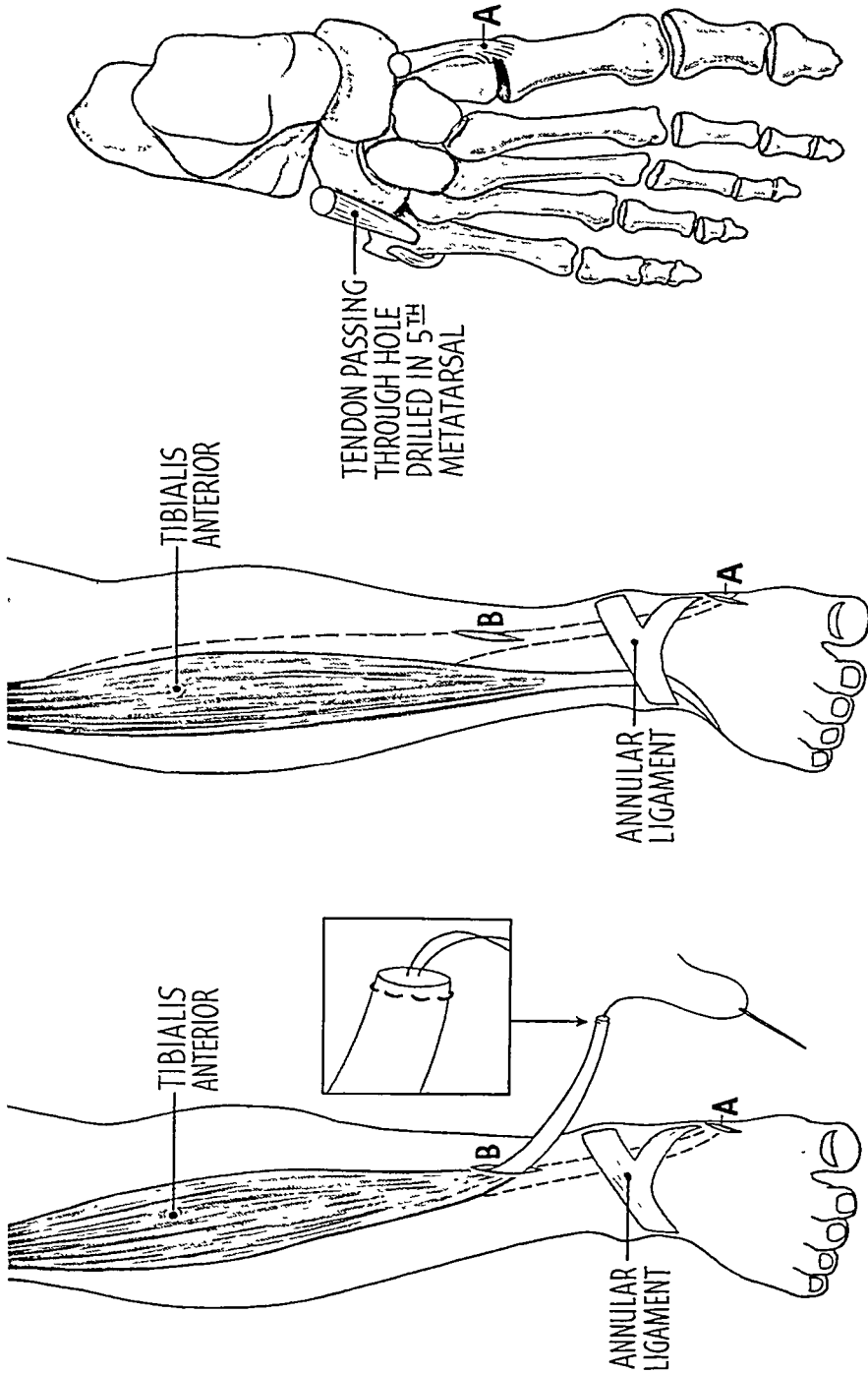


Fig. 1-C

Fig. 1-B

Fig. 1-A

Illustration of method of anchoring the tendon of the anterior tibial muscle through the fifth metatarsal. Figs. 1-A and 1-B: *A*, Insertion of anterior tibial tendon in first cuneiform and first metatarsal; *B*, Incision through which tendon is pulled. Fig. 1-C: Insertion of tendon through the proximal end of the fifth metatarsal.



FIG. 2-A

FIG. 2-B

FIG. 2-C

Fig. 2-A: Child seven years old with recurrence in all components of deformity. Figs. 2-B and 2-C: Three years after anterior tibial transplantation, showing satisfactory correction of the deformity.

one inch in length is made over the anterior tibial tendon just above the ankle joint. A similar incision is made over the insertion of the anterior tibial tendon and the tendon detached. (In several instances there was found an abnormal insertion of the tendon, such as a thin, wide attachment under the first metatarsal, or a divided tendon.) The tendon is then pulled out through the upper incision. A silk suture, the ends of which should be long, is passed through the end of the tendon. A curved hemostat is passed through the upper incision and distally under the annular ligament toward the proximal end of the fifth metatarsal. A short incision over the fifth metatarsal is made and a hole drilled through the bone. The tendon is passed through the newly made channel and through the drilled hole in the metatarsal. When the tendon is too short, it is transferred to the cuboid. The tendon, secured with silk suture and chromic catgut, is threaded carefully through the hole in the bone, and the loose silk suture ends are used to anchor it laterally to the periosteum, or to the soft tissues of the sole. The subcutaneous tissues and skin are closed in layers. A circular plaster cast is applied, maintaining as much correction of the deformity as possible. Every two weeks the cast is removed and a fresh wedge cast is applied. Patients in this series wore postoperative casts for an average of eight weeks.

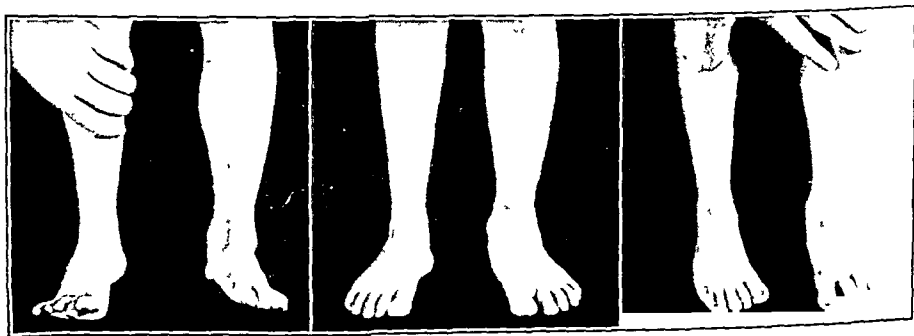


FIG. 3-A

FIG. 3-B

FIG. 3-C

A four-year end result. The operation was performed when the child was seven years old, with excellent result.



FIG. 4-A

FIG. 4-B

FIG. 4-C

A bilateral three-year end result. Fig. 4-A: Shows metatarsus adductus present. Fig. 4-B: Shows the correction of the heel inversion. Fig. 4-C: Shows the action of the anterior tibial tendon in everting the feet.

In evaluating the following figures, it must be understood that the deformity had resisted long-continued and vigorous treatment.

Transplantation of the anterior tibial tendon was performed on fifty-six feet in forty-four patients. The influence of the operation on the adduction of the forefoot was graded excellent in nineteen feet, or 34 per cent.; good in twenty-four, or 43 per cent.; and not satisfactory in three, or 5 per cent. The effect on the adduction was not noted in ten feet, or 18 per cent.

The effect on the inversion was excellent in thirty feet, or 54 per cent.; good in twenty-two, or 39 per cent.; and had no apparent effect in four, or 7 per cent.

The effect of the operation alone on the equinus was difficult to evaluate, because wedge casts were applied for an average of eight weeks after surgery. The final end result is influenced remarkably by the degree of equinus present before the operation. Correction of the equinus is essential. In three instances, a tibial-turn operation was subsequently performed to correct the torsion of the tibia, with excellent results.

The indications for this operation are simple. If deformity recurs after vigorous conservative treatment, the mechanism of the anterior tibial tendon should be determined. If, on active dorsiflexion, the foot is inverted and the forefoot is adducted, this operation should be contemplated. If the peroneal muscles cannot evert the foot, the operation is indicated.

In no case has it been necessary to reanchor the tendon into its original insertion. All patients have been followed from one to five years.

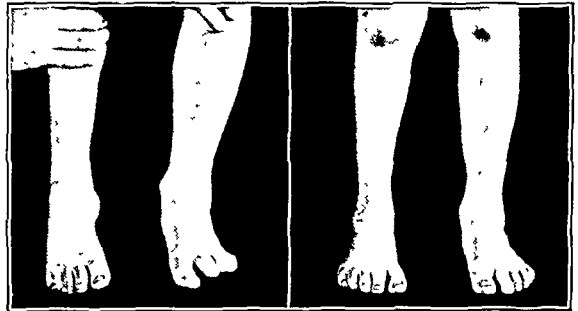


FIG. 5-A

FIG. 5-B

A bilateral three-year end result. The operation was performed when the child was six years old, with excellent result.

The tendency to continued improvement is considerable, due to the mechanism of the transferred anterior tibial tendon, as well as the removal of the deformity-causing anterior tibial pull. The late end-result studies of the fifty-six feet so treated indicated excellent results in thirty-four feet, or 61 per cent.; and good results in eighteen, or 32 per cent. Satisfactory results were obtained in fifty-two, or 93 per cent., of the fifty-six feet subjected to transposition of the anterior tibial tendon. There were no poor results from the sacrifice of the anterior tibial tendon although in four feet, or 7 per cent., no beneficial effects were noted.

#### CONCLUSIONS

1. The deformity in club-foot does sometimes recur after apparently adequate conservative treatment.
2. The faulty mechanism of the anterior tibial muscle is a mechanical factor in this recurrence.
3. Correction of the equinus is necessary to obtain the best mechanical advantage of the transferred force.
4. End-result studies of fifty-six feet indicate that the continuous influence of the transferred force is an important factor in the correction of resistant cases.
5. No bad effects were noted from the sacrifice of the anterior tibial tendon.
6. Satisfactory end results were obtained in 93 per cent. of the feet so treated.

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## LAMBRINUDI OPERATION FOR DROP-FOOT\*

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In 1927 and again in 1933 Mr. C. Lambrinudi of Guy's Hospital, London, proposed a "new operation on drop-foot". The operation has been successfully performed and accepted by many orthopaedic surgeons. The object of this paper is to present the indications, the contra-indications, and the technique of the operation and to emphasize the surgical principle on which it is based.

The principle as expressed by Lambrinudi is that "The best method to stabilize a joint without ankylosing it is to allow it to lock in a normal manner". The principle then is a physiological or natural bone check. When in complete equinus, the foot cannot drop any further because the posterior portion of the astragalus abuts against the tibia. The anterior capsule of the ankle joint is taut in plantar flexion and may be an important factor, as well as the natural bony obstruction, in the locking mechanism. The Lambrinudi operation controls drop-foot by correcting the equinus deformity at the subastragalar joint and arthrodesing the tarsus in a functional position to the astragalus, which is locked in complete equinus within the mortise of the ankle joint.

### INDICATIONS AND CONTRA-INDICATIONS FOR THE OPERATION

Lambrinudi devised this operation for the correction of drop-foot or equinus deformity in a foot with an active gastrocnemius soleus muscle and inactive or paralyzed dorsiflexor and peroneal muscles. If the peroneal muscles are active and strong, then this operation is not indicated because a more constructive and logical procedure is triple arthrodesis combined with anterior transposition of the peronei with implantation of their tendons to the dorsum of the tarsus. The Lambrinudi operation would definitely improve a flail or dangle foot but the writer believes that a dangle foot is best treated by a panastragalar and calcaneocuboid arthrodesis with the foot in slight equinus. The operation is not indicated if the patient has an unstable knee joint which requires the support of a brace. If there is considerable shortening of the extremity, the operation may not be indicated if the equinus deformity serves to compensate for the shortening, with an addition to the height of the heel of the shoe.

A mild equinus position of the foot due to contracture of the Achilles tendon provides stability to the knee when the quadriceps femoris is paralyzed. If this situation is present, the equinus deformity should never be completely eliminated by any surgical procedure. The foot

\* Presented at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Boston, Massachusetts, on January 24, 1940.



FIG. 1

Lateral roentgenogram taken with the foot in complete equinus. A wedge of bone is removed from the head, neck, and body of the astragalus so that the inferior surface of the astragalus forms a plane at an angle of about 95 or 100 degrees with the vertical axis of the leg. The tarsus is then arthrodesed to the remaining portion of the astragalus.

foot equinus should not be confused with an equinus deformity of the entire foot, since it will demand a different surgical technique for correction.

As suggested by Fitzgerald and Seddon, the operation is of special value in deformities of the foot due to paralysis of origin other than the residual paralyzes of anterior poliomyelitis. The drop foot of hemiplegia, permanent common peroneal nerve injury, congenital equinovarus deformity which has resisted manipulative corrections, and equinus de-

which Lambrinudi selected for this operation may present a varus deformity due to an active and unopposed tibialis posterior muscle. The overaction of this muscle would be a deforming factor and therefore it should be eliminated by exposure and excision of a small segment of the tendon through a one-inch incision preliminary to the main dissection. Lateral instability of the astragalus within the mortise of the ankle joint is not infrequently the reason for the failure of stabilizing operations at the subastragal joint, and the Lambrinudi operation would be no exception. If this undesirable factor is present, a better functioning foot can be secured by a panastragal arthrodesis which stabilizes the ankle joint as well as the subastragal articulation. The age of the patient is an important consideration; the operation, like other arthrodesing methods, should not be performed before the age of about eight years. An extreme fore-

formities with loss of dorsiflexor and peroneal muscles, due to trauma and burns, may find solution by the Lambrinudi operation.

#### TECHNIQUE

A lateral roentgenogram of the affected foot and ankle in complete equinus is essential for study in planning the planes of bone section before the actual surgical operation. The roentgenogram (Fig. 1) shows the astragalus locked in the extreme of plantar flexion and one can determine with accuracy the degree of the angle and the size of the wedge of bone which is to be removed from the head, neck, and body of the astragalus, so that the inferior surface of the astragalus will form a plane of about 95 degrees in relation to the vertical axis of the leg (Fig. 2). The foot should be placed at an angle of 95 degrees to the leg if there is complete paralysis of

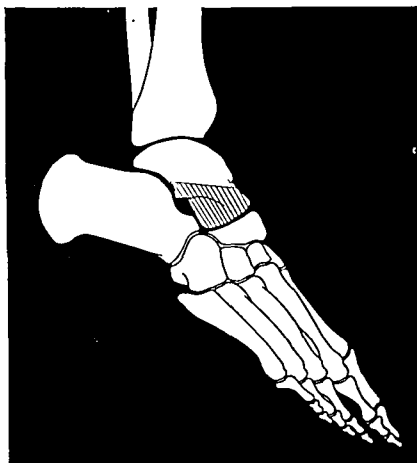


FIG. 2

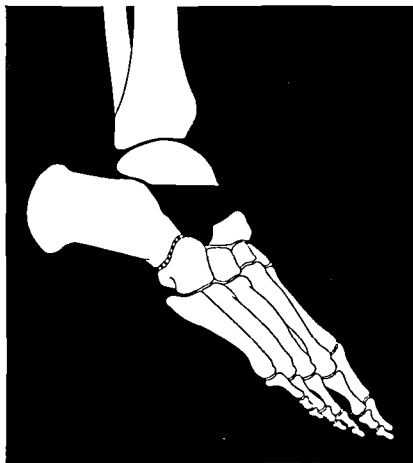


FIG. 3

Fig. 2: The shading indicates the portion of the head, neck, and body of the astragalus removed to correct the equinus deformity at the subastragalar joint. The inferior surface of the remaining portion of the astragalus forms a plane of about 100 degrees in relation to the vertical axis of the leg. The equinus deformity is corrected when the tarsus is arthrodesed to the astragalus, which is locked within the ankle joint mortise.

FIG. 3

Fig. 3: After the wedge of bone is removed from the astragalus, the superior surface of the os calcis is denuded of cartilage and bone to form a plane parallel with the horizontal axis of the foot. Cartilage is removed from the calcaneocuboid joint. Finally a notch is made horizontally from side to side in the posterior and inferior portion of the scaphoid bone. This notch will receive the sharp anterior border of the astragalus.

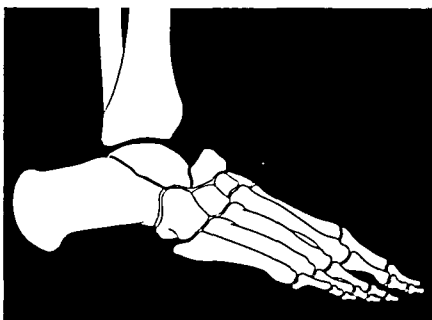


FIG. 4

The Lambrinudi operation controls drop-foot by correcting the equinus deformity at the subastragalar joint and arthrodesing the tarsus in functional position to the astragalus, which is locked in complete equinus within the mortise of the ankle joint.

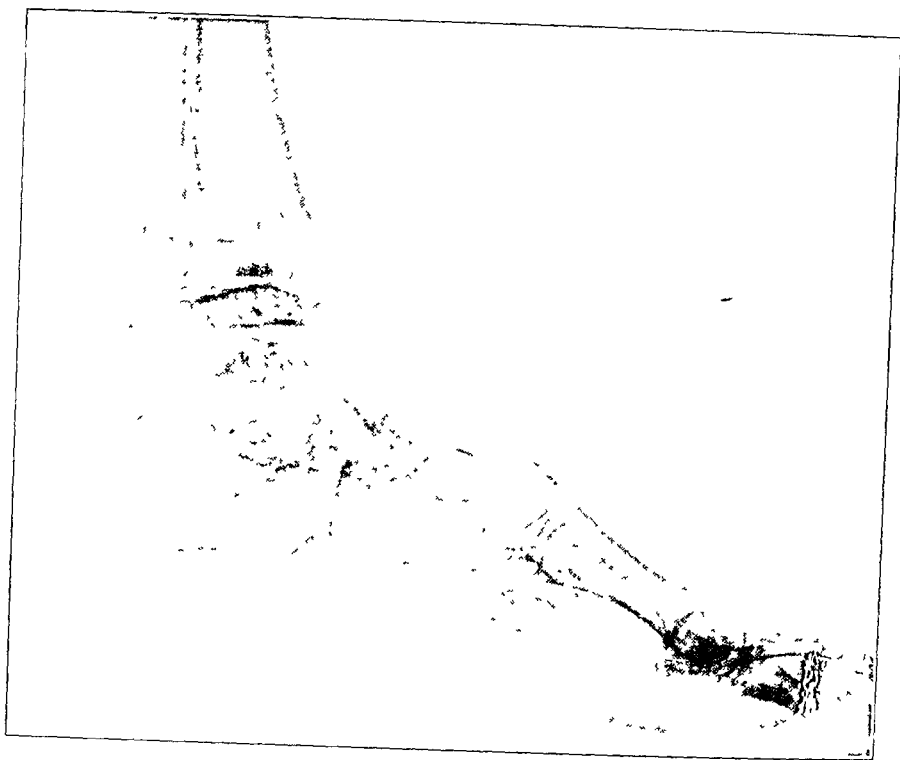


FIG. 5

Roentgenographic evidence of bony union between the astragalus and the tarsus with correction of the drop-foot deformity at the subastragalar joint.

the dorsiflexor and peroneal muscles; however, an angle of 100 degrees should be planned if there is some available power in the dorsiflexor muscles or the peronei which may be transplanted to the dorsum of the tarsus. The foot should never be placed at a right angle to the leg because such a position does not permit the wearing of an ordinary heel and also because it prevents the active gastrocnemius from coming into action as a "push off" mechanism when walking.

The subastragalar joint is exposed in the usual manner through a long lateral curved Kocher incision. Complete medial dislocation of the tarsus at the subastragalar joint is essential after sectioning the peroneal tendons, opening the astragaloscaphoid and calcaneocuboid joints and dividing the interosseous and external lateral ligaments of the ankle. The wedge of bone, which was determined when the lateral roentgenogram was studied, is removed from the head, neck, and body of the astragalus after the inferior surface of the astragalus is completely denuded of cartilage (Fig. 2). Cartilage and bone are then removed from the superior surface of the os calcis to form a plane which is parallel with the horizontal axis of the foot. The cartilage is removed from the calcaneocuboid joint, and, finally, a notch is made horizontally from side to side in the posterior and inferior portion of the scaphoid (Fig. 3). The sharp anterior margin of the remaining portion of the astragalus is then firmly wedged into the prepared notch of the scaphoid while the superior bleeding

surface of the os calcis is approximated to the inferior bleeding surface of the astragalus (Fig. 4). The foot is now at the desired angle of 95 or 100 degrees to the axis of the leg and cannot be plantar-flexed further, since the astragalus is locked at the ankle joint in complete equinus. The incision is closed and a long plaster-of-Paris leg cast is applied to maintain the position of the foot and permit postoperative elevation of the extremity. About the beginning of the third week, a short walking cast is applied with a rubber or felt heel incorporated within the plaster. Periods of elevation are gradually decreased while periods of walking with weight-bearing on the cast are gradually increased. Plaster fixation is continued until there is roentgenographic evidence of bony union (Fig. 5) at the subastragalar and calcaneocuboid joints, which requires between three and five months.

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# A CLINICAL STUDY OF ONE HUNDRED PATIENTS SUBJECTED TO SIMPLE EXOSTOSECTOMY FOR THE RELIEF OF BUNION PAIN

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The following study was undertaken in an attempt to evaluate the operation of simple exostosectomy. This procedure attempts to relieve the bunion pain by removing the projecting medial portion of the first metatarsal head. It does not correct the hallux valgus.

Before starting the study of the operated group, many roentgenograms of feet exhibiting hallux valgus were reviewed. Some of the patients showed hallux valgus on one foot and not on the other. From these preoperative roentgenograms, the following conclusions are drawn:

1. The size of the exposed portion of the metatarsal head is approximately in direct proportion to the degree of great-toe valgus.

2. In the majority of feet with hallux valgus, the first metatarsal heads show straightening of the medial border, and, in addition, many of the heads appear almost square (Fig. 1). The amount of new bone present, which changes the shape of the head or causes enlargement of it, rarely exceeds one-sixteenth of an inch in thickness. The changes that are seen in the shape of the first metatarsal head represent areas of pressure atrophy and absorption of the cortex with bone repair. The projecting medial portion of the metatarsal head, therefore, is not an exostosis in the true sense of the word.



FIG. 1

Illustrates square appearance of metatarsal head. This foot is an ideal example of the type suitable for simple exostosectomy.

3. Many of these first metatarsal heads show circular punched-out areas just under the medial cortex. These areas represent subcortical fibrocystic degeneration of bone (Fig. 4-A).

4. If the proximal phalanx maintained its normal articulation with the first metatarsal head, and did not sublunate laterally, there would be no medial prominence of the metatarsal head, and no bunion would develop.



FIG. 2-A



FIG. 2-B

Calcification in bursae overlying first metatarsal heads.

5. The size of the bunion, as reflected in the soft-tissue outline in the roentgenogram, may be large or small, depending upon the degree of inflammatory reaction in the soft tissue. The bursa overlying the prominent portion of the metatarsal head occasionally calcifies (Figs. 2-A and 2-B).

The 100 patients in the group operated upon were examined by the authors from nine months to six years after operation. The average post-operative period for the whole group was thirty months. The series comprised ninety-two women and eight men. At time of operation the youngest patient was fourteen years of age, and the oldest was sixty-nine. No wound infection occurred in the 199 feet operated upon. These patients were not consecutive cases, because not all the patients who were asked to return did so.

The operative technique used in these 100 cases may be described in general as follows:

Under local or general anaesthesia, a two-inch dorsomedial incision is started one-half inch distal to the first metatarsophalangeal joint. This incision is carried proximally in a gentle curve to pass above the dorsal outline of the bursal sac and thence straight up the metatarsal shaft (Fig. 3, A).

The dorsal vein is preserved and, in most instances, is retracted laterally. The bursal sac is excised if it contains calcareous material, is nodular, or is greatly thickened, but otherwise it is left intact.

The capsule is incised in line with the skin incision. The joint space

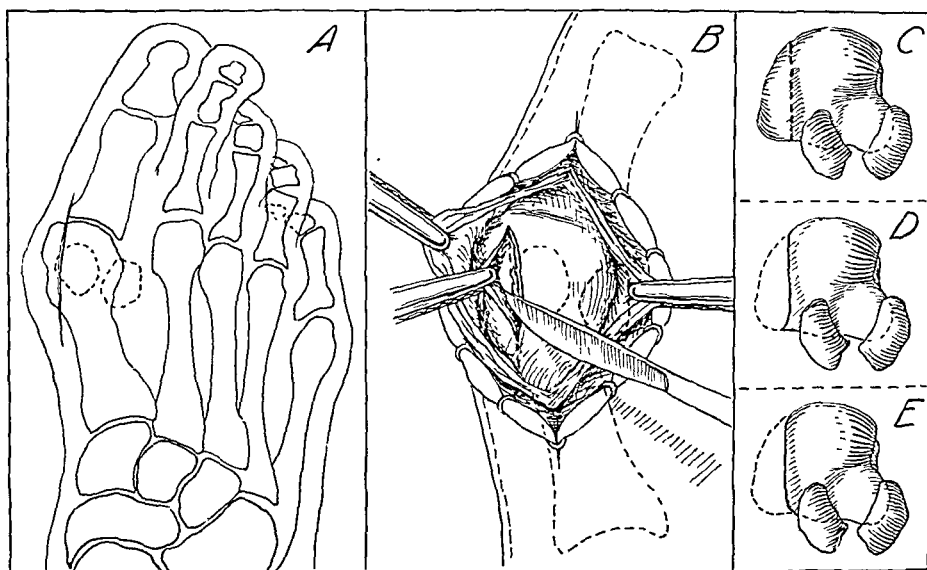


FIG. 3

Diagram illustrating operative procedure.

is located, and the knife is carefully inserted between the medial side of the capsule and the joint space. The knife is kept close to the metatarsal head, while it separates the capsule from the bone for a sufficient length to expose the entire medial side of the metatarsal head and a small portion of the adjacent shaft (Fig. 3, B).

The amount of bone to be removed is determined from the gross appearance of the metatarsal head. The cartilage of the metatarsal head articulating with the phalanx is white, glistening, and smooth. The cartilage not functioning as articular surface is of darker color, dull in appearance, rough and spotty in distribution. A small vertical groove often accentuates the demarcation between these two areas.

The osteotome is placed on the metatarsal head in such a manner that it is parallel to the vertical axis of the metatarsal shaft and is pointing slightly medially. It is then driven through the bone, removing the whole medial portion of the metatarsal head not functioning as articular surface (Figs. 3, C and 5).

In older patients, especially, splitting of the metatarsal shaft is guarded against by notching the cortex of the shaft where the osteotome will eventually come out, and by not using the osteotome as a lever.

The bone is inspected. Any sharp edges are rounded off. All loose pieces of bone are removed.

The wound is closed in layers. Fine chromic gut suture is used for the capsule, fine plain gut suture for the superficial layers, and silk for the skin.

The toe is bandaged with the purpose of holding it toward a varus position and in slight plantar flexion. The wound is dressed the following day. Active toe motion is encouraged.



The sutures are removed on the tenth day, and the patient is allowed up in comfortable shoes. Physiotherapy is given, which consists of foot and toe exercises, massage of the feet, and contrasting foot baths.

### THE RESULTS

#### A. *Satisfactory*

In this series of 100 patients, seventy-seven were entirely relieved of all bunion pain and discomfort. Eleven patients had vague aches and pains about the first metatarsophalangeal joints which suggested arthritis. The ages of these latter patients varied widely, and no absolute cause for their mild discomfort could be determined. All eleven of these patients were pleased with the operation, and considered the results excellent. We consider that these eighty-eight patients had satisfactory results because they were contented with the operation and would recommend it to others.

#### *Course After Operation*

1. *Length of Disability:* The average time before close-fitting shoes were worn was six weeks. The majority of patients did not return to work until seven weeks after operation. Many stated they were more

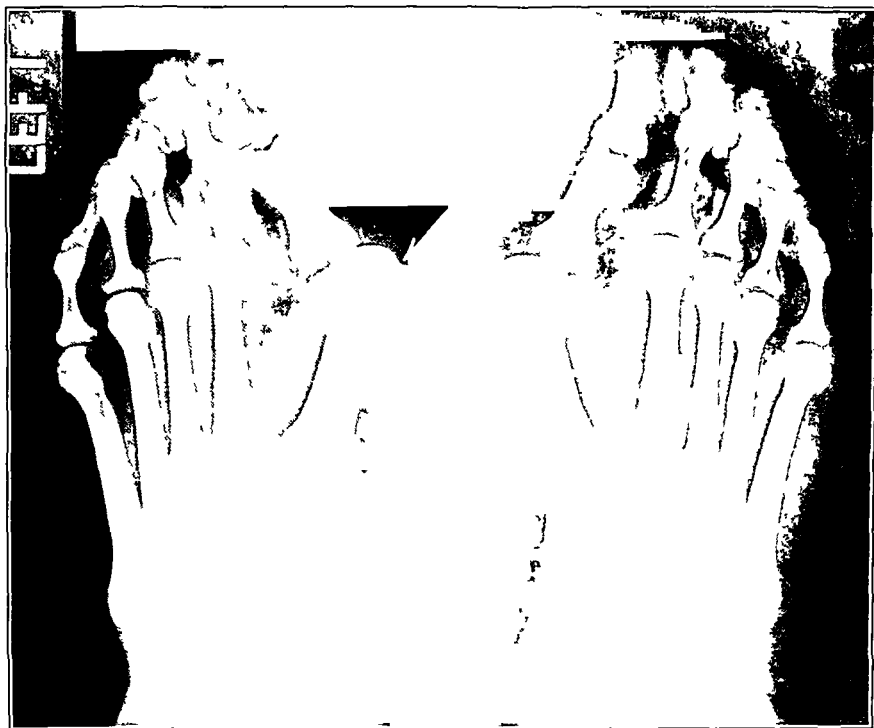


FIG. 4-A

Illustrates marked degree of hallux valgus with dislocation of second toe on left. Arrow points to area of subcortical fibrocystic degeneration. Note marked rotation and marked subluxation of great toes with displacement of sesamoid bones

comfortable three weeks after operation than they had been before operation. Many others contended that they could have gone to work earlier if necessary. Eight to ten weeks after operation all evidence of callosity and bursa had disappeared from the exostosectomy site.

2. *Great-Toe Motion:* Before operation many patients, particularly in the older group, showed osteo-arthritic changes such as slight lipping of the joint margins. The motion existing before operation, which in every case was ample, was not diminished by surgery more than 10 degrees in any case. This loss of motion was clinically insignificant.

3. *Metatarsalgia:* Many feet with hallux valgus show pronated rear-feet, splayed and supinated forefeet, and hypermobile first metatarsal bones. When these people stand, an undue portion of the body weight is borne on the second and third metatarsal heads. This leads to varying degrees of metatarsalgia. Some patients complained of this condition before operation, but apparently, in most of the patients, it was absent or overshadowed by the bunion pain. Following recumbency in bed and relief from bunion pain, metatarsalgia for a few weeks became, with a number of patients, a predominant complaint. Physiotherapy and correctly fitted metatarsal pads aided these patients.

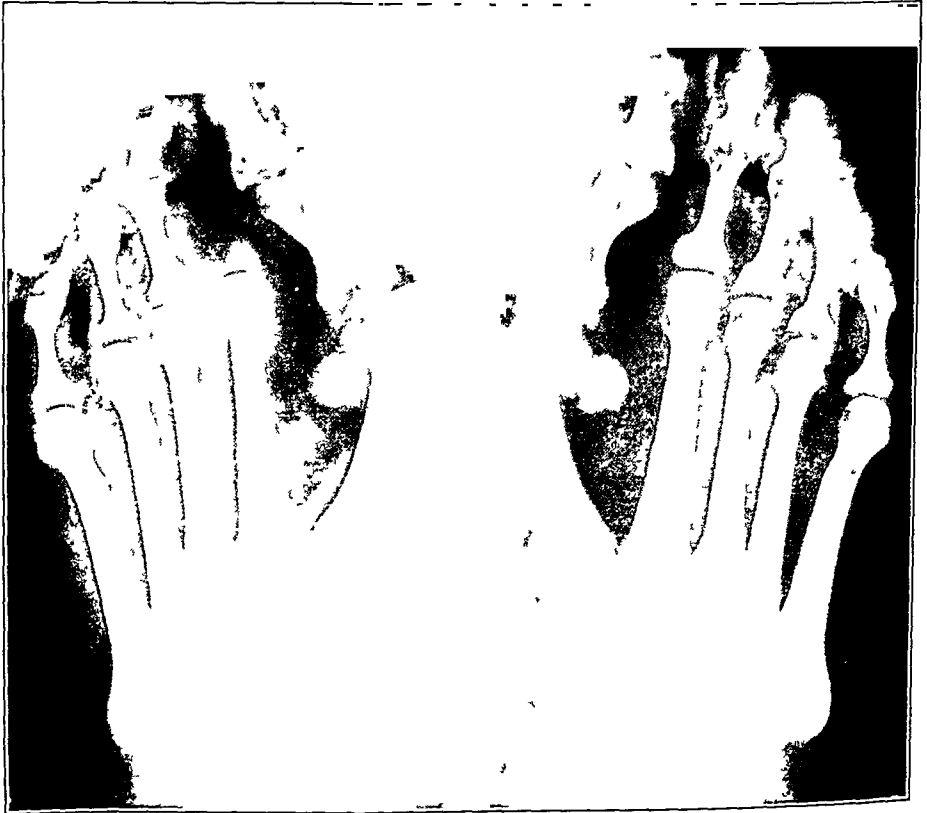


FIG. 4-B

Same case as shown in Fig 4-A, two months after simple bilateral exostosectomy of first metatarsal head and amputation of second left toe

4. *Roentgenographic Findings After Operation:* By comparing the pre-operative x-rays with those of the same feet taken one to six years after operation, it was found that the configuration at the exostosectomy site remained about the same. A thin layer of surface condensation at the exostosectomy site marked the area of bone repair. This layer never exceeded one-thirty-second of an inch in thickness. There were no changes suggesting sclerosis of bone or osteo-arthritis as are so frequently seen following partial transverse resection of the metatarsal head.

In many instances, the degree of hallux valgus was measured from comparable roentgenograms taken before operation and at the time of the last examination. The degree of hallux valgus was found to be practically the same as before operation.

Splaying of the forefoot, as measured from these roentgenograms, was found to be mild, and in none of these eighty-eight cases an important factor.

#### *B. Unsatisfactory*

The remaining twelve patients presented disappointing results. Eleven of these patients had both feet operated upon. Of the twenty-



FIG. 4-C

Same case as shown in Figs. 4-A and 4-B, four months after simple exostosectomy and amputation of second left toe. Both feet were painful, with dislocation of left great toe. Note how the sesamoid bones have shifted in position.

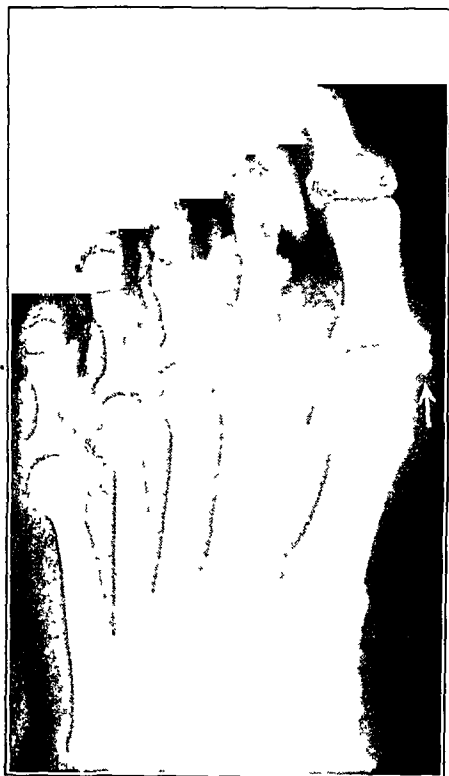


FIG. 5

Roentgenogram taken one year after exostosectomy. Arrow points towards loose piece of bone not removed at time of operation. Note extent of exostosectomy, and that the exostosectomy site blends with the metatarsal shaft.

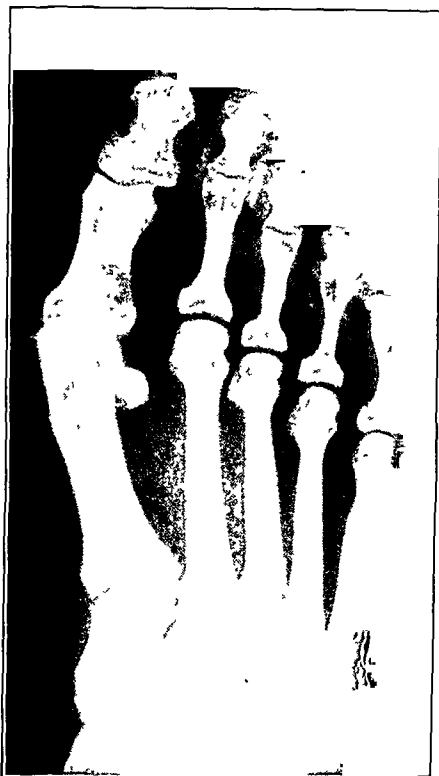


FIG. 6

Illustrates inadequate removal of medial side of first metatarsal head. This prominence was later removed with complete relief of symptoms. Note also exostosectomy of fifth metatarsal head.

three feet operated upon, nineteen were painful. The cause of the pain and disability following operation was due either to a faulty selection of the patient for this operation (three cases), or to some fault in operative technique.

1. *Selection of the Patient:* From the study, we conclude that patients subjected to simple exostosectomy should fulfill the following requirements:

- a. The patient should be interested primarily in the relief of bunion pain, not in the correction of the deformity.
- b. Circulation in the feet must be adequate.
- c. Sesamoiditis should not be present. Failure to observe this condition previous to operation may at times influence one to regard this operation as the cause of the sesamoid pain. Usually this is not the case. Careful examination and special roentgenographic views for the study of the sesamoid bones before operation will help one to rule out this condition (Fig. 8).

- d. The great-toe motion at the first metatarsophalangeal joint

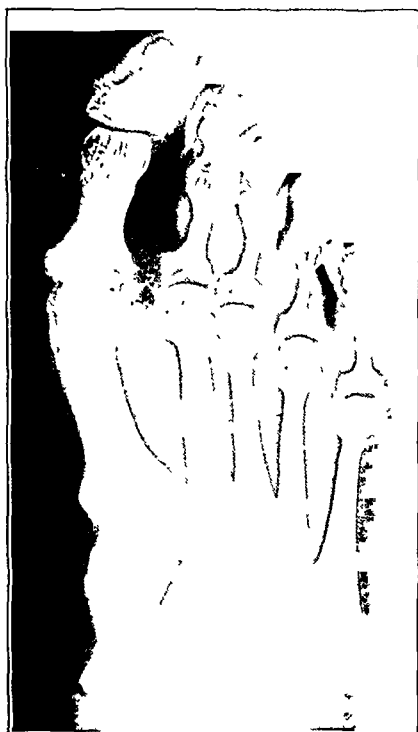


FIG. 7-A

Illustrates too generous removal of medial side of first metatarsal head without trimming of adjacent phalangeal base. The prominent phalangeal base was responsible for the persistence of symptoms.



FIG. 7-B

Same foot as in Fig. 7-A, one year after trimming of prominent phalangeal base. Excellent great-toe motion. Patient completely relieved of pain and discomfort.

should be free and painless. Great-toe motion should be considered definitely limited when the great toe will not dorsiflex passively through an arc of at least 50 degrees on the metatarsal shaft. Passive enforcement of this motion should not cause pain. In estimating the dorsal range of great-toe motion, the first metatarsal bone must not be supported or elevated. Roentgenograms of feet with limited great-toe motion frequently show osteo-arthritic changes or osteophyte production, contributing to the limitation of great-toe motion. These feet should not be chosen for simple exostosectomy.

e. The hallux valgus should be under 50 degrees when estimated by the angle which the great toe makes with the metatarsal shaft. Further, the anatomical relationship between the great toe and the second toe must be normal. If the great toe overlies or underlies the second toe, or if the second toe is cocked up, is absent, or needs to be amputated, a simple exostosectomy is not indicated. If this operation is done, marked increase in the hallux valgus may occur. This increase in valgus may become so pronounced as to cause lateral dislocation of the great toe on the metatarsal head (Figs. 4-A, 4-B, and 4-C).

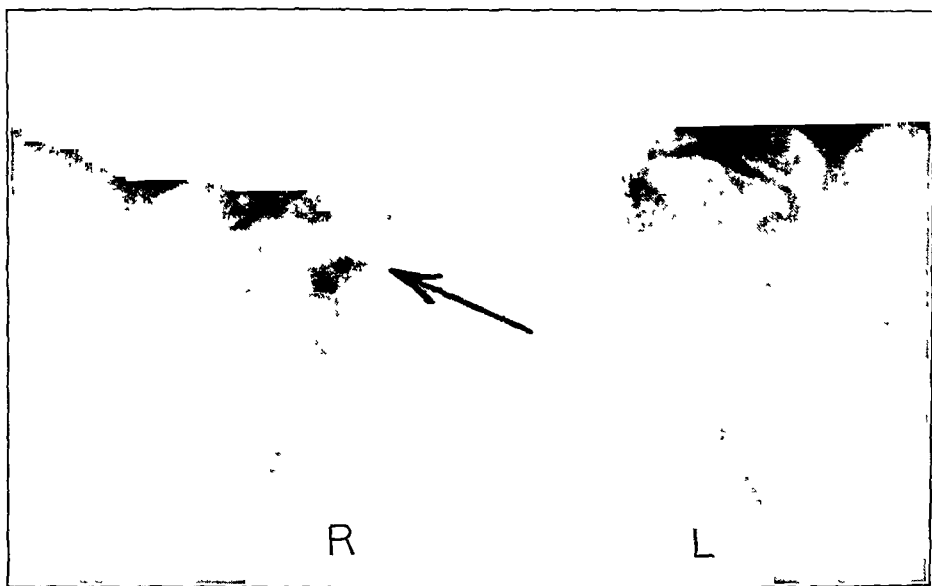


FIG. 8

Special sesamoid view, taken to show prominent medioplantar border on right first metatarsal bone. Note how site of exostosectomy has been gouged out, leaving a prominent ridge on the medioplantar border. The left first metatarsal shows a satisfactory exostosectomy. Note the smooth flat surface with well-rounded medioplantar border. (Compare with Figures 3, D and 3, E.)

f. If the above are considered, advanced age in itself does not contra-indicate the procedure.

## 2. *Operative Faults:*

a. The failure to remove a loose bone spicule at time of operation may lead to a painful bony nodule (Fig. 5).

b. Inadequate removal of the medial side of the metatarsal head may result in the bunion persisting. The most common place where insufficient removal occurs is the dorsomedial portion of the metatarsal head. This bony prominence may be unduly pressed by the shoe, and a small painful bunion may result (Fig. 6).

c. Too generous removal of the medial side of the metatarsal head may cause the medial side of the base of the first phalanx of the great toe to be prominent, and cause pain from shoe pressure (Fig. 7-A). This can be avoided if careful palpation of the phalanx and the cut surface of the head is done at operation, and the two surfaces made flush with each other (Fig. 7-B). With hallux valgus, the sesamoids are displaced laterally to a greater or lesser extent. If the exostosectomy is correctly done and not too much of the head is removed, no fear of removing the articulating surface for the medial sesamoid need be entertained (Fig. 8).

d. The most frequent cause of persisting pain due to operation, and the mistake that is most easily made, is leaving a sharp medioplantar border on the first metatarsal head. This is caused by an inadequate chisel cut that fails to take off the complete side of the metatarsal head. The result is that a cortical ridge is left on the medioplantar border of the

metatarsal head (Fig. 8). That the pain is caused by shoe pressure against this ridge is demonstrated by the fact that these people can walk bare-footed without pain. The point of tenderness occurs most frequently where one expects the medial sesamoid to be, only to discover in the roentgenogram a prominent medioplantar border with the medial sesamoid well lateral to it (Fig. 8). Removal of this prominent ridge gives complete and permanent relief from pain. If the medioplantar border of the metatarsal head is exposed, and this area is rounded off at the time of exostosectomy, the prominent ridge will be avoided (Fig. 3, *E*).

3. *Roentgenographic study of these feet showed the following:*

a. The hallux valgus increased in those cases where abnormal anatomical relationship existed between the first and second toes, or in those where the hallux valgus was 50 degrees or over. In these cases, the splay of the foot also increased.

b. If the roentgenogram immediately after operation showed a prominent medioplantar border, subsequent roentgenograms showed the same condition. In no case did a prominent bony ridge develop spontaneously after operation.

#### CONCLUSION

Simple exostosectomy is a satisfactory procedure for the relief of bunion pain. It has a definite place among the operations for painful bunion. The operation seems to the authors to be most applicable to those people with a mild to moderate degree of hallux valgus, who are beyond the third decade of life, and in whom correction of the hallux valgus is not essential.

# THE LOCAL USE OF SULFANILAMIDE IN VARIOUS TISSUES \*

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A review of the literature on sulfanilamide is beyond the scope of this paper, but certain facts in connection with this drug should be mentioned. Most of these have been gleaned from the literature and some from our own experience. We believe that the following may be accepted as true:

1. When the drug is administered by mouth or parenterally to man or to laboratory animals it enters the blood stream and is excreted rather rapidly.

2. When sulfanilamide is given in therapeutic doses, the blood of the recipient becomes bacteriostatic for beta-hemolytic streptococci and for certain other susceptible bacteria. As a result, many patients infected with susceptible bacteria recover when the drug is administered. Likewise, laboratory animals treated with sulfanilamide survive lethal doses of susceptible bacteria.

3. Since the drug is excreted rather rapidly, effective treatment requires that the dose of the drug be repeated about every four to six hours and that an adequate concentration (about ten milligrams per 100 cubic centimeters) be maintained in the blood until the infection is eliminated. This means that the drug must be continued for several days after the disease has apparently been arrested, as living but static or dormant bacteria may still remain in the tissues and may begin to grow and reproduce the disease.

4. In therapeutic doses the drug is slightly toxic to most patients and is very toxic to certain patients who are hypersensitive to it. However, it is to be noted that the few fatalities which have been recorded in the literature have occurred rather late in the use of the drug and in patients who have received from 30 to 100 grams of sulfanilamide.

5. The manner in which sulfanilamide acts is not known. It affects the bacteria directly, and does not increase the resistance of the infected animal. Consequently, the drug must come in contact with the bacteria in the animal body.

6. In therapeutic doses the drug is not bactericidal. It merely inhibits the rate of growth of susceptible bacteria which are then eliminated by the natural resistance of the animal. Consequently, treatment of the disease may be rendered more effective by measures, such as immune serum, which increase the resistance of the animal.

\* Read at the Annual Meeting of the American Orthopaedic Association, Kansas City, Missouri, on May 9, 1940.



7. The drug diffuses from the blood into the body cavities and into the tissues of the animal. The concentration probably varies in different tissues, but it is less than that present in the blood at the same time.

8. The drug exerts its principal effect on generalized infections and has relatively little effect upon local lesions.

9. The results obtained by the administration of sulfanilamide to infected animals cannot be obtained by exposing bacteria to similar concentrations of the drug in culture media. However, studies of the action of sulfanilamide *in vitro* have shown the following:

(1) The effectiveness of the drug varies in different media and a small amount of peptone or peptone-like substances in the medium greatly decreases the power of the drug. In other words, if bacteria are grown in an unfavorable peptone-free medium and then subjected to low concentrations of sulfanilamide, the action of the sulfanilamide on the bacteria under these conditions may approach that which is obtained by the low concentration present in the blood of infected animals that have received the drug in therapeutic amounts.

(2) The effectiveness of the drug varies directly with the concentration present in the medium and high concentrations of the drug may be bactericidal, especially if the medium is one which is favorable to the action of the drug and is unfavorable to the growth of the bacteria.

(3) The effectiveness of the drug varies inversely with the number of bacteria present and a massive implant of bacteria may grow in a concentration of the drug which would prevent growth of a small inoculum.

(4) When the bacteria are exposed to the drug there is a period of from six to eight hours during which the bacteria continue to multiply before the drug begins to act.

(5) An increase of even a few degrees in the temperature markedly increases the power of the drug, and bacteria which are killed when exposed to a given concentration of the drug at 40 degrees may grow well in a similar concentration of the drug at 37 degrees.

(6) The drug is highly selective and in therapeutic concentrations it has little or no effect upon many pathogenic organisms. However, high concentrations of the drug may inhibit the growth of staphylococci and of Welch's bacilli which are not affected by the concentrations obtainable in the blood of treated animals.

(7) The drug neutralizes the toxins of certain pathogenic bacteria, notably the staphylococcus and Welch's bacillus.

During the past year we have been interested in the local effects of sulfanilamide, both as a preventive of infection in contaminated and clean operative wounds and as a method of treating wounds which are infected.

The local use of the drug was first brought to our attention about three years ago by Knowles<sup>1</sup> who told one of us that he had been injecting neoprontosil solution into the tissues around wounds where he feared gas gangrene might develop and that he had also injected it into the muscles and subcutaneous tissues of wounds in which gas gangrene had developed

following operative drainage or amputation. He said that he had been satisfied with the use of the preparation in this manner. We were also impressed by the results which Jensen, Johnsrud, and Nelson<sup>2</sup> obtained by the local use of sulfanilamide in compound fractures. Making no other change in their technique of débridement, suture, and after-treatment, they had reduced the incidence of infection in compound fractures from an average of 27 per cent. to only 5 per cent. One cannot fail to be impressed by such figures, and we have routinely used the drug in contaminated wounds during the past year. However, we have also used the drug in clean wounds, not routinely, but especially in operations where there was considerable damage to the tissues and where foreign materials, such as bone grafts and wire or screws, were left in the wound. In other words, we have endeavored in certain instances to make our surgery bacteriostatic rather than aseptic or antiseptic, and our clinical results have been satisfactory. However, before using the drug in clean wounds, the following two points should be settled: (1) Should the drug be sterilized before it is placed in the wound, and (2) Does the drug damage the local tissues?

In attempting to answer the first question we placed an excess of the drug in culture media and inoculated this with various concentrations of streptococci, staphylococci, and Welch's bacilli. When these were incubated at 37 degrees centigrade, bacterial growth was inhibited in all of the tubes during the first forty-eight hours, but only the streptococci were killed while the other organisms continued to grow. Consequently, we believe that the drug should be sterilized and we have done this by placing the dry powder in a flask and putting it in the autoclave. This, we realize, is not an adequate sterilization for bacteriological purposes, but it appears to be satisfactory for clinical purposes, where we combine the bacteriostatic action of the drug with the clearing mechanism of the wound in which it is to be placed. A few bacteria may survive and be carried in with the drug, but their growth will be inhibited and the clearing mechanism of the patient will take care of them without difficulty.

In answer to the second question, we first attempted to determine whether or not local implantation of sulfanilamide interfered with the healing of the bone. In a series of experimental fractures in rabbits we were not able to determine that those in which sulfanilamide had been implanted in the wound at the time of the fracture healed any differently from the similar control fractures in the opposite leg of the same animal<sup>3</sup>. However, we have noted in clinical cases that more fluid tended to collect in wounds in which sulfanilamide had been implanted than was usual in similar clean postoperative wounds. This fluid was dark red in color and occasionally drained out through small openings between the skin edges. Usually, however, the skin wound remained closed and the fluid was absorbed.

It thus appeared that sulfanilamide did have some slight deleterious action on the healing of the wound. Consequently, we decided to ex-

periment with a series of animals, implanting the sulfanilamide in various types of wounds and studying these wounds both macroscopically and microscopically in an attempt to determine if it seriously damaged the tissues or interfered with the healing of those tissues. We were especially interested in its effect on the lining of joint cavities and on the articular cartilage. Two series of experiments were performed. In the first experiment, fractures of two ribs were produced in each of twelve rabbits and sulfanilamide was placed in one wound before it was sutured, but not in the other. In the same animal one knee joint was opened and the incision was extended downward to expose the anterior tibial tendon. This tendon was cut and was then sutured with fine silk. Sulfanilamide powder was placed in the knee joint and around the suture of the tendon and the wound was closed with silk. A similar operation without implanting sulfanilamide was performed on the other knee as a control. In two animals the control knee became infected and the experiment had to be repeated. The animals were sacrificed at intervals of from one to fifteen days. The tissues of the joints and ribs were then examined macroscopically and were studied microscopically. In none of the experimental animals were we able to note from our macroscopic examination that the sulfanilamide in the wound had any deleterious effect except possibly to delay the primary healing during the first few days. It was our impression that in the wounds containing sulfanilamide there was apt to be more fluid in the tissues and there seemed to be more bleeding in the tissues after the wound was closed. Apparently the sulfanilamide interfered slightly with the formation of the blood clot, and in some of these wounds in the first few days there was a soft gelatinous clot which was not as firm as were similar clots in wounds which did not contain sulfanilamide.

Likewise, in our microscopic study of the tissues we were not able to detect any constant differences in the two sets of wounds,—that is, we found that healing progressed at about the same rate in the wound into which sulfanilamide had been inserted as in the control wound. There was no difference in the amount or type of callus in the early fractures of the ribs which were studied. All of the wounds contained leukocytes and fibroblasts in approximately the same amounts as did the control wounds for the same period. In the later wounds the scar-tissue formation in the wounds treated with sulfanilamide appeared to be about the same as that present in the control wounds of the same type. We were particularly interested in the changes of the knee joints and in these we found that after our operation there was a definite synovial irritation with blood and exudate in the joint during the first few days. In the vascular and fatty areas of the synovial membrane, the synovial cells were slightly increased in size and number and the subsynovial tissues were slightly infiltrated with leukocytes and round cells, and there was also some dilatation and engorgement of the veins and capillaries near the synovial surface. This occurred even in areas on the opposite side of

the joint from the suture line. However, these changes were no more marked in the joints which contained sulfanilamide than they were in those which did not, and by the end of the tenth or twelfth day the joints had returned to about their normal appearance.

Likewise, in the experiments in which the tendon was sutured, the tendons appeared to unite just as well in the sheaths containing sulfanilamide as in the others.

In a second experiment, we produced operative wounds in muscles, subcutaneous tissues, fasciae, and joints of twelve dogs. Each wound was controlled by a similar one in the opposite leg, but in the experimental wounds a relatively large amount of sulfanilamide powder was placed before they were sutured. These animals were sacrificed at intervals so that we had experimental wounds of from one to fifteen days' duration. Gross and microscopic examinations of these wounds revealed no constant difference in healing between those which contained the sulfanilamide and those which did not. There was, however, the same tendency to excess collection of fluid in the early wounds. The wounds in the muscles treated by sulfanilamide appeared to heal at about the same rate as the control wounds and this was also true of those in the fascia and subcutaneous tissue. Also, the joints of the dogs showed a low-grade inflammatory reaction as did those of the rabbits, and this tended to disappear with the return to approximately normal condition by the tenth or twelfth day. In the dogs the inflammatory reaction was somewhat more apparent, probably because the wounds were larger, but it was no more marked in the wounds which contained the sulfanilamide than it was in those which did not. There was no evidence in any of our animals that the sulfanilamide in the joint had had any deleterious effect upon the articular cartilage.

In order to test further the reaction of the joints to sulfanilamide, we injected saturated solutions of this drug and 5-per-cent. solutions of neoprontosil into the knee joints of a series of rabbits. These experiments were controlled by the injection of normal salt solution into the joint of the opposite knee of each animal. Since the fluid had practically all disappeared at the end of the first day, these experiments were not carried beyond the period of forty-eight hours, but several animals were used with each drug. Here, too, there was slight irritation of the synovial lining cells of the joints,—that is, they were slightly increased in size and number, and there was a small amount of subsynovial infiltration of leukocytes and round cells in the vascular areas in the synovial surface. There was also some engorgement of the capillaries in these areas. However, in these joints also the reaction to the injected fluid was no more marked in the joints with sulfanilamide than it was in the joints into which normal salt solution had been injected, nor was there any evidence of actual destruction of the lining of the joints or damage to the articular cartilage. We used neoprontosil because sulfanilamide is soluble to only about 1 per cent. while neoprontosil can be obtained in 5-per-cent. solution for injection.

We would have liked to experiment with much more highly concentrated solutions of the drug, but could not do so because we were not able to obtain a suitable sulfanilamide derivative which could be used in solution and which was soluble to more than 1 per cent. Some of the newer derivatives, such as sulfapyridine and sulfathiazol, can be obtained as the sodium salts, which are very soluble,—33-per-cent. solutions of sodium sulfapyridine can be obtained for intramuscular injections, but this drug has a hydrogen-ion concentration of about eleven and is so alkaline that it would act as a severe irritant to the tissues. When it is injected intramuscularly in patients who cannot take the drug by mouth, it probably produces small aseptic abscesses in the muscles into which it is injected. Consequently, it would not be suitable for local use in joints.

As a result of our observations we have felt free to implant sulfanilamide at will in clean operative wounds provided the powder was sterile. The powder should be crushed if it is lumpy from sterilization and it should be spread thinly over the surface of the wound after hemostasis has been effected and just before the wound is sutured. Its collection into masses which act as foreign bodies should be avoided. In suturing the wound, dead spaces should be obliterated when possible. Where the wound is to be left open or partly open, as after operations for osteomyelitis, larger amounts of the powder are used. This is also true when it is used as a bacteriostatic agent in treating an open wound postoperatively.

We have also injected saturated solutions of sulfanilamide into infected knee joints and have felt free to inject 5-per-cent. solutions of neoprontosil into infected knee joints. We have not yet arrived at a point where we have placed sulfanilamide in clean knee joints after operations on semilunar cartilages, but we have routinely placed it in hip joints opened for arthroplasties and in other wounds, and have noted no untoward effects. In fact, we have felt much more at ease in the post-operative course of these patients than we would have if we had not placed the sulfanilamide in the wound.

In none of the patients in whom we have used the drug has there been any indication of a toxic effect, nor have we had any infections. Of course we might not have had any infections if we had not used the drug.

It should be mentioned that powdered sulfanilamide in a wound is similar to a test-tube experiment in which a concentration of the drug of approximately 1000 milligrams is brought into contact with any bacteria which may be present in the media. In such concentrations the drug is effective against small numbers of staphylococci and of Welch's bacilli, and against large numbers of streptococci. However, if the number of staphylococci or Welch's bacilli is relatively large, infection may occur. Likewise, the drug is acting in a medium which is favorable to the growth of the bacteria and is unfavorable to the action of the drug, because tissues break down into peptone-like substances. However, since the drug exerts a neutralizing effect on the toxins of both staphylococci and

Welch's bacilli, the amount of tissue breakdown is limited by the presence of the drug. Also, since the drug converts bacteria into a static or non-pathogenic phase in which they do not invade the surrounding tissues and do not multiply, these bacteria are taken care of by the normal clearing mechanism of the animal and are destroyed. When we consider the facts that local infected lesions contain large numbers of bacteria growing in a favorable medium which contains peptone-like substances and that only a relatively low concentration of the drug can be maintained in such lesions, the reason that the systemic administration of sulfanilamide is not very effective against local lesions is obvious.

#### CONCLUSIONS

1. Sulfanilamide should be sterilized before it is placed in clean wounds.

2. Joints and other tissues which we have investigated tolerate the drug very well.

3. The powder slightly inhibits the primary healing of the wound, but not to such a degree as to contra-indicate its use in clean operative wounds.

4. It may be used repeatedly in open infected wounds and does not seriously interfere with the healing of such wounds.

5. We not only advocate the local implantation of sulfanilamide in contaminated wounds, but we also advocate its use in clinically clean operative wounds where infection is especially to be feared or would be particularly undesirable.

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## SULFANILAMIDE AND INTERNAL FIXATION IN THE TREATMENT OF COMPOUND FRACTURES \*

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The beneficial action of any bactericidal agent upon pyogenic infection should be evaluated with extreme conservatism since, with or without any form of treatment, virulent infections may subside suddenly by crisis. The virulence of different strains of the same bacteria varies widely, and the defense of the individual against a given organism is unpredictable. A number of so-called cures have been advocated,—among them formalin, silver nitrate, mercurochrome, and gentian violet; these, however, have been proved harmful, of only slight value, or of no value at all. Unusual care, therefore, has been exercised in the evaluation of our results from sulfanilamide therapy in the treatment of compound fractures.

The favorable influence of sulfanilamide therapy on such virulent infections as acute osteomyelitis and acute infectious arthritis, or infections elsewhere through the body, have been reviewed and discussed extensively in the literature. Our experience is confined chiefly to the preventive or prophylactic action of sulfanilamide on infection in compound fractures. Fifty-four cases have been reviewed, including those wherein internal fixation was also employed. Prior to this study it was thought that fairly dogmatic conclusions could be reached. Complete and unbiased investigation, however, has demonstrated that this report must be regarded as a preliminary one, although the evidence is sufficiently favorable to warrant further use of the drug. At the present time, a much larger and more comprehensive series of cases is being accumulated in which sulfanilamide, as well as other chemotherapeutic agents (sulfapyridine and sulfathiazol), are being utilized.

The fractures in the fifty-four patients who received sulfanilamide as a prophylactic measure may be divided into three groups: (1) fresh compound fractures; (2) old compound fractures with a previous infection; and (3) compound fractures with an active draining infection. There were thirty-five in the first group, twenty-eight of whom were observed within the first twelve hours of the injury; consequently, no differentiation is made as to the element of time. In a portion of this series, from fifteen to twenty grams of sulfanilamide crystals were placed directly into the compound wound, and the wound was closed without drainage. After twenty-four hours sulfanilamide was continued by mouth, fifteen to twenty grains every four hours. Blood concentrations were made on the second and third days, and the dosage decreased if indicated. Cultures were not taken from the fresh wounds. Of the ten cases wherein infection developed, cultures revealed staphylococcus aureus in five,

\* Read by title at the Annual Meeting of the American Orthopaedic Association, Kansas City, Missouri, on May 9, 1940.

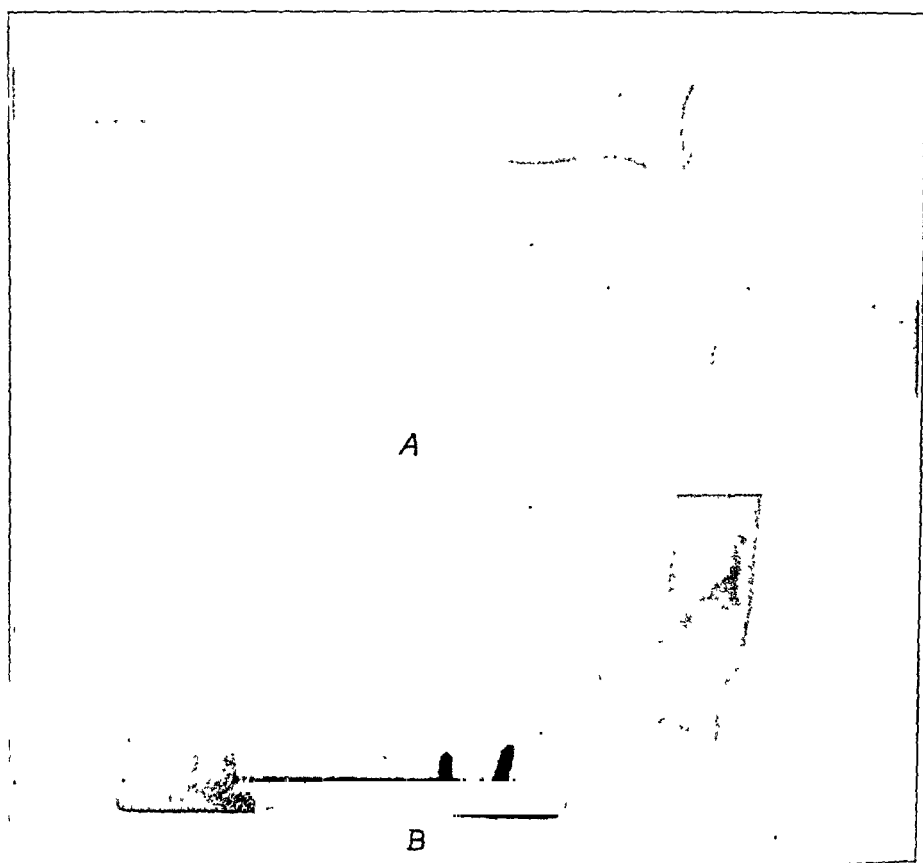


FIG. 1

A. Roentgenogram of a compound fracture of the ulna of moderate degree, with fracture-dislocation of the head of the radius (Monteggia's fracture).

B. Roentgenogram, taken seven months later, shows practically normal function.

Welch's bacillus in three, and streptococcus haemolyticus in one. In one instance the organism was not recorded. These figures would suggest that sulfanilamide had a less favorable prophylactic action upon staphylococcus and Welch's bacillus than upon streptococcic infections.

The second group consisted of seven compound fractures, all of which had been infected, and had eventually healed with malunion or non-union. As these fractures were treated elsewhere, the bacteriological findings of the initial infection were available in only one case,—a combined staphylococcus and Welch's bacillus infection. In such a group one could ordinarily anticipate a flare-up of the infection in a small percentage of cases following extensive reconstruction operations. Sulfanilamide or neoprontosil was administered routinely, the average dose being eight grams of the former or ten grams of the latter, for twenty-four to forty-eight hours prior to the operation, and for three to seven days after operation until there was no longer danger of infection. No infections ensued in these seven cases.

In the third group of fractures surgery was employed in the face of an active draining infection. The dosage of sulfanilamide or neoprontosil



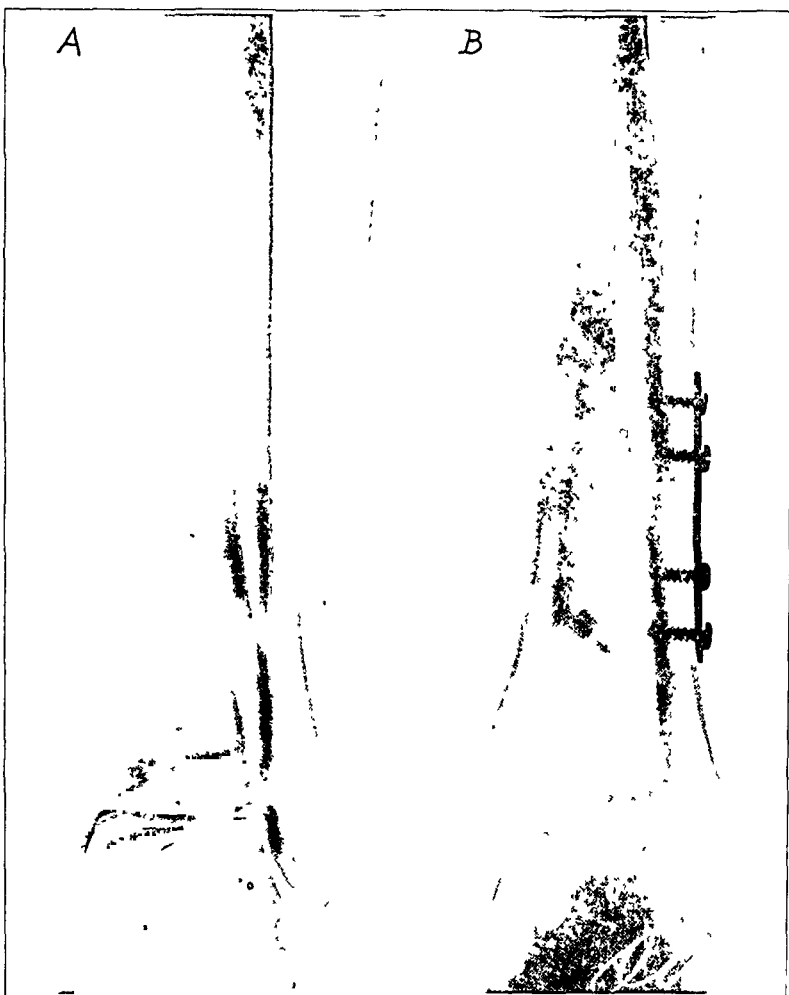


FIG. 2

A. Roentgenogram of a compound fracture of the tibia (severe type) and fracture of the fibula. Injury was sustained by an explosion of a stove. Fibula was plated through separate clean incision. Compound wound was débrided, sulfanilamide crystals placed in the wound, and the skin closed with plastic flap. Primary healing took place. Sulfanilamide was given by mouth for five days.

B. Roentgenogram taken seven months later.

was similar to that administered in the presence of compound fractures with latent infections. The bacteriological studies in this group showed staphylococcus aureus in three cases, staphylococcus haemolyticus in two, and streptococcus haemolyticus in two. The findings in five cases were not recorded.

Prior to the introduction of vitallium, internal fixation by ordinary ferrous metal plates had been attended by so many undesirable and even disastrous complications that the method fell into rapid disrepute. The success of vitallium for internal fixation in selected simple fractures, however, led to the use of the metal in conjunction with sulfanilamide

TABLE I  
RESULTS OF TREATMENT IN EIGHTY-FIVE CASES OF FRESH COMPOUND FRACTURES

Results	Sulfanilamide Therapy				No Sulfanilamide			
	Cases		Average Time (Months)		Cases		Average Time (Months)	
	No.	Per Cent.			No.	Per Cent.		
Not infected . . . . .	25	71.4			33	66.0		
Union . . . . .	18	51.4	3.1		28	56.0	2.7	
Non-union . . . . .	4	11.4			3	6.0		
Incomplete . . . . .	3	8.6			2	4.0		
Infected . . . . .	10	28.6			14	28.0		
Union . . . . .	4	11.4	2.7		8	16.0	5.0	
Osteomyelitis . . . . .	0	0.0			2	4.0		
Non-union . . . . .	3	8.6			0	0.0		
Amputation . . . . .	3*	8.6			2	4.0		
Incomplete . . . . .	0	0.0			2	4.0		
Died . . . . .	0	0	0.0	0.0	3†	3	6.0	6.0
Totals . . . . .	35	35	100.0	100.0	50	50	100.0	100.0

\* Three patients had amputations for gas gangrene, one died three months later from other causes.

† Two patients died from gas gangrene and one from streptococcic septicaemia.

TABLE II  
RESULTS OF TREATMENT WITH SULFANILAMIDE IN MILD, MODERATE, AND SEVERE  
FRESH COMPOUND FRACTURES

Results	Mild Fractures	Moderate Fractures		Severe Fractures	
	No Internal Fixation	Internal Fixation	No Internal Fixation	Internal Fixation	No Internal Fixation
Not infected . . . . .	8	6	0	5	6
Union . . . . .	6	4	0	4	4
(Average time, months) . . . . .	(3.6)	(2.4)		(3.5)	(3.0)
Non-union . . . . .	0	2	0	1	1
Too early . . . . .	2	0	0	0	1
Infected . . . . .	0	1	1	4	4
Union . . . . .	0	1	0	1	2
(Average time, months) . . . . .		(1.0)		(4.0)	(3.0)
Non-union . . . . .	0	0	1	2	0
Amputation . . . . .	0	0	0	1	1
Gas gangrene *. . . . .	0	0	0	0	1
Totals . . . . .	8	7	1	9	10

\* Patient died three months later from other causes; the gas gangrene had healed.

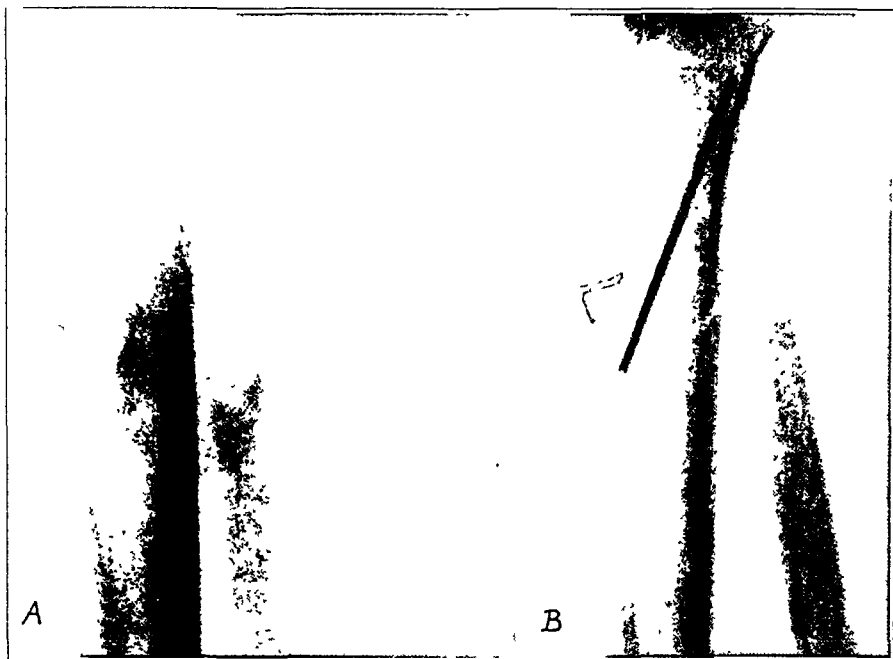


FIG. 3

A. Roentgenogram of a severe compound fracture of the tibia and fibula. Wound involved the knee joint with a six-inch exposure of the tibia.

B. Roentgenogram showing open reduction and fixation by vitallium pin and one stainless-steel wire loop. The wound drained for several months with solid union in six months.

in compound fractures. Some form of metallic internal fixation was applied to thirty-one bones in thirty of the fifty-four patients to whom sulfanilamide was administered. Sixteen of the patients with fresh fractures had internal fixation; eleven of these had vitallium plates and screws; one, vitallium screws; two, stainless-steel nails; and two, stainless-steel wires. Of the seven patients who were found to have potentially infected fractures, fixation by means of plates was employed in three, and bone grafts held by vitallium screws in one. Ten of the twelve patients with actively infected fractures were treated by internal fixation: five, by vitallium plates (two bones were so fixed in one of these patients); one, by stainless-steel nails; one, by stainless-steel wire; two, by Steinmann pins which were incorporated in the cast; and one, by a vitallium screw.

#### FRESH COMPOUND FRACTURES

In order to evaluate the results of sulfanilamide therapy in fresh compound fractures, a comparative analysis has been made between this group to whom sulfanilamide was administered, and a similar, but larger control group in which this form of therapy was not employed. Unfortunately, we do not have available an older control group in which internal fixation was employed. The results of this study are summarized in Table I.

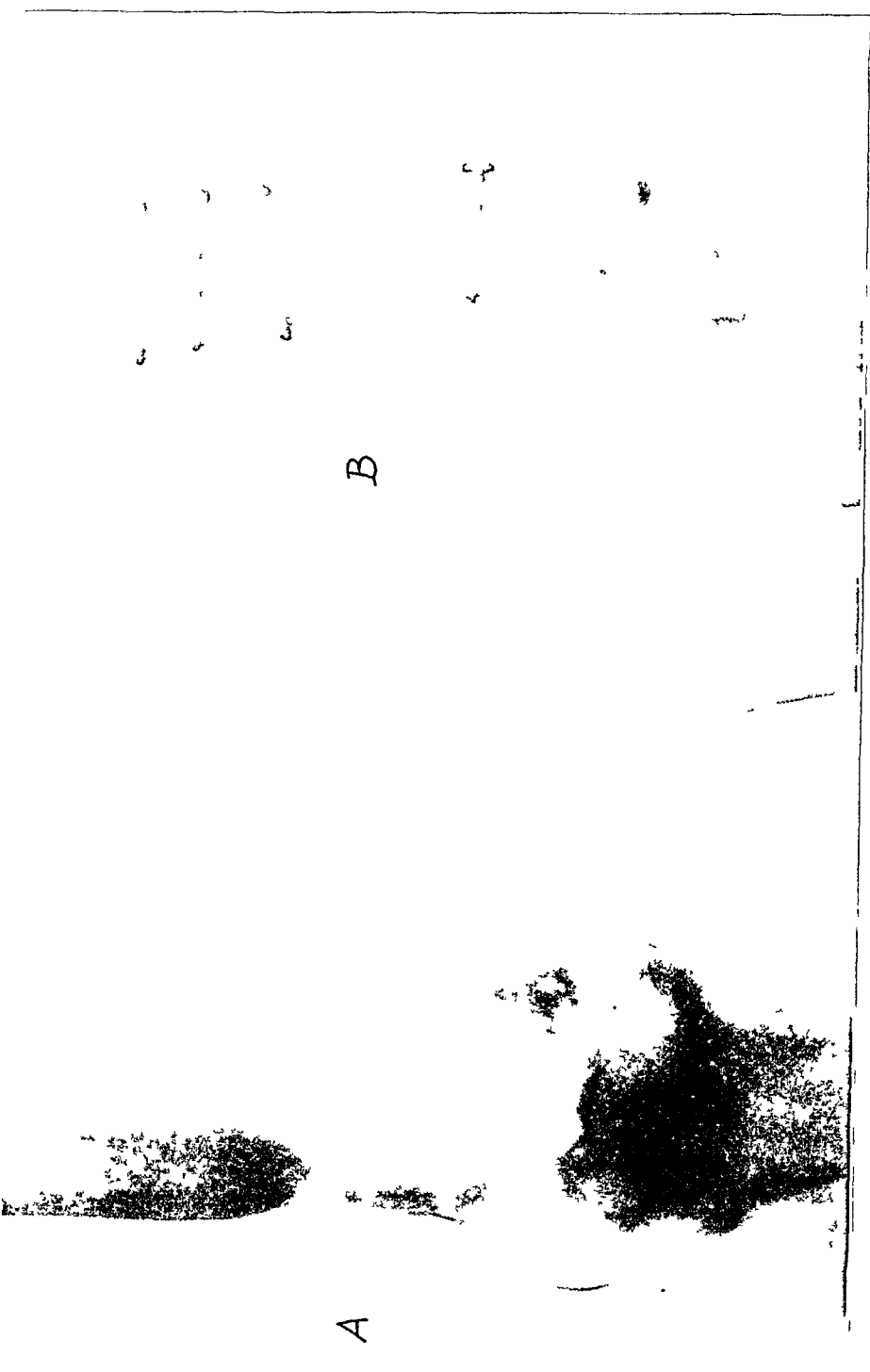


FIG. 4

A. Roentgenogram of an ununited fracture of the humerus of ten months' duration, which was secondary to a compound fracture, and followed by gas gangrene and staphylococcal osteomyelitis.  
 B. Roentgenograms taken one year and eight months after bone graft which utilized the shaft of the fibula. No flare-up of infection followed the graft. Two screws were removed from the distal portion of graft because of their proximity to the skin surface.

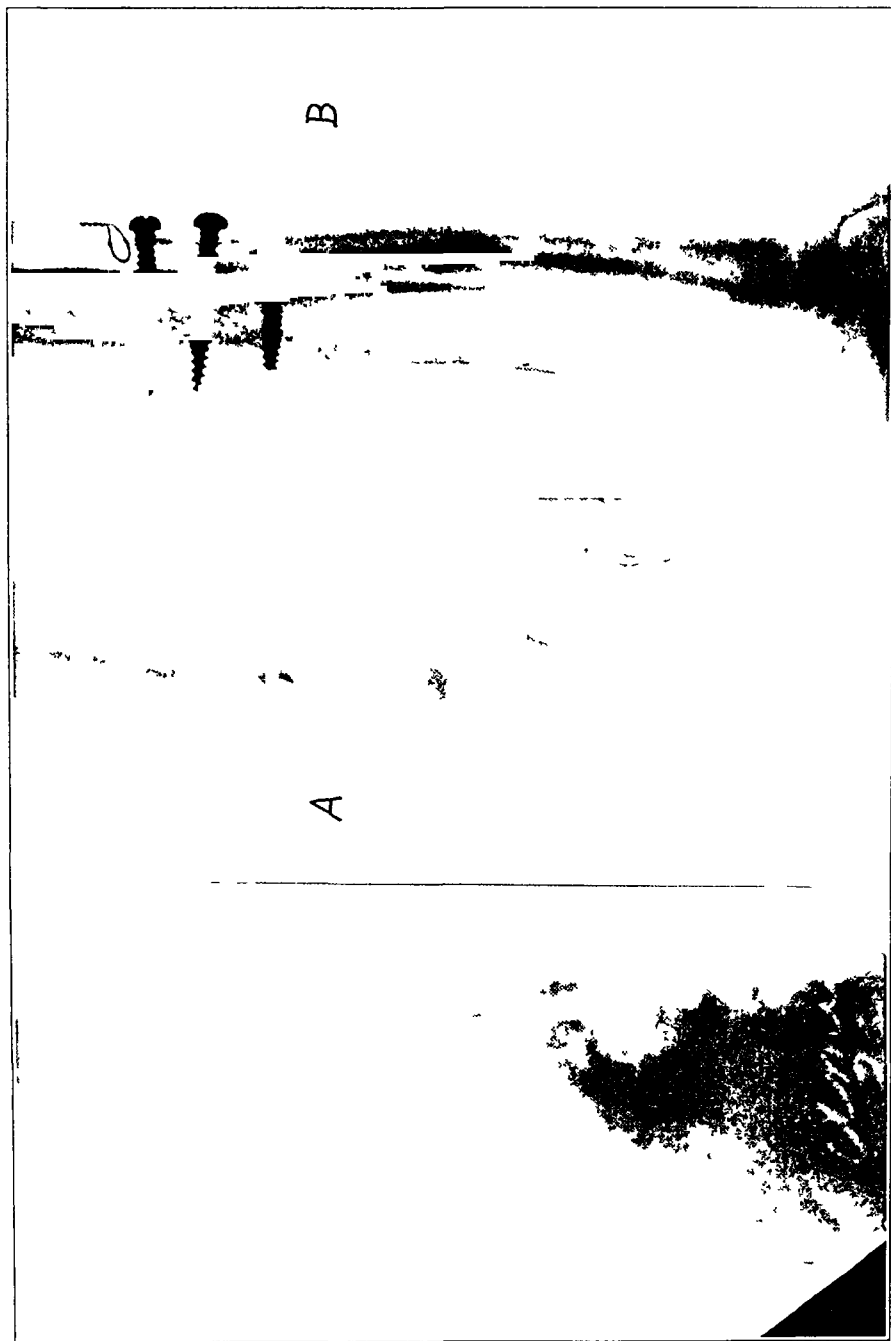


Fig. 5

A. Roentgenograms taken two years after an old compound fracture show loss of lower inch of tibia following osteomyelitis. There was a depressed scar about one inch deep over the defect.

B. Roentgenogram taken after two operations with primary healing in each instance. In the first operation, the old scar was dissected out, and the fibula transferred to the center of the defect. This was followed by plastic closure of the skin. The second operation, one year later, transferred the fibula at its mid point to the tibia.

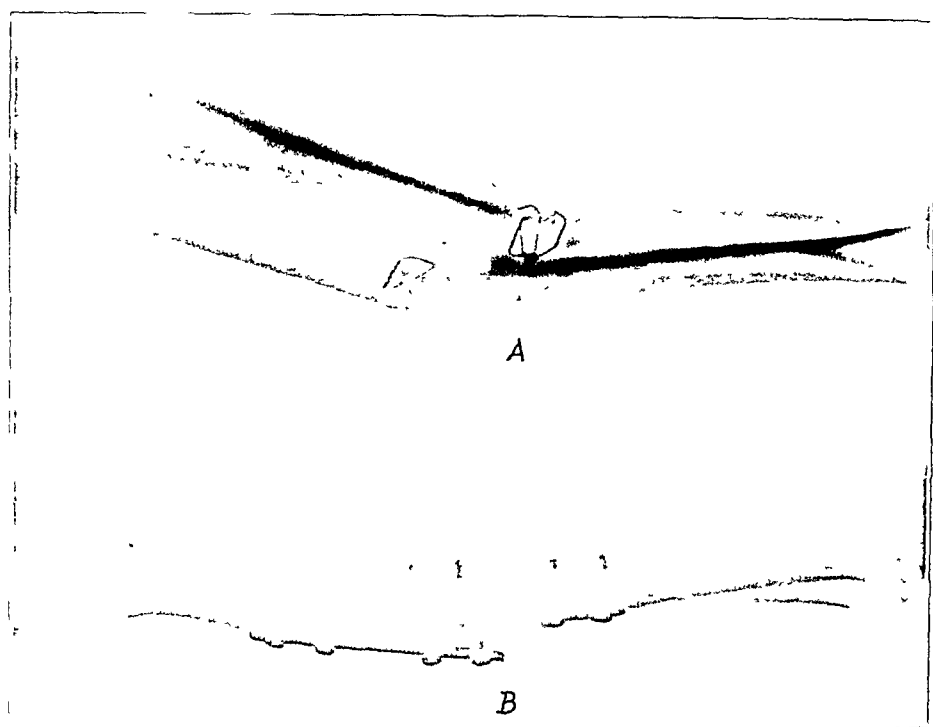


FIG. 6

- A. Roentgenogram of a compound fracture with active draining infection and multiple draining sinuses five months after an open operation in another hospital. After preoperative sulfanilamide therapy, sequestra and wires were removed, fractures reduced, and vitallium plates applied. Sinuses healed in four weeks.
- B. Roentgenogram taken six months postoperatively.

An analysis of Table I shows that the percentage of infections in the control group and in the sulfanilamide group was approximately the same. The evidence, therefore, suggests that sulfanilamide has little effect on preventing infection. The average period of union in the sulfanilamide group wherein infection developed was two and seven-tenths months, however, as compared with five months in the control cases. This would suggest that sulfanilamide is definitely instrumental in arresting infection, although a much larger series of cases must be assembled before the evidence can be considered at all conclusive. The average time required for union of the uninfected fractures was slightly more than that for the control group. This feature might be accounted for by a possible difference in the character of the fractures in the two groups, or by the fact that internal fixation, which may of itself delay union, was employed freely in those cases wherein sulfanilamide was given. The number of fractures which failed to unite was approximately the same in both groups. None of the patients who received sulfanilamide died as a result of a compound fracture, and in none did osteomyelitis develop; three, however, had amputations for gas gangrene. Of the patients in the control group, three died,—two from gas gangrene, and one from streptococcic septicaemia; and in two osteomyelitis developed.

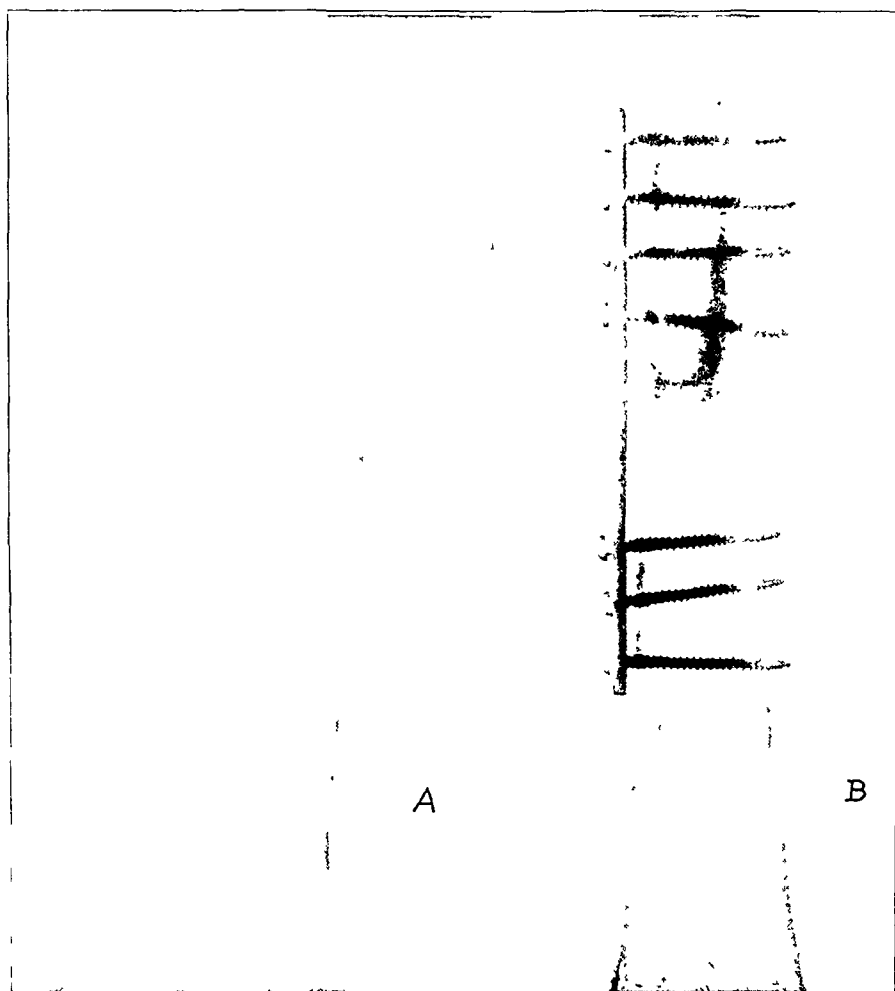


FIG. 7

*A.* Roentgenogram of a fracture of the femur of seven months' duration, with multiple draining sinuses and large granulating wounds from loss of skin surface over anterior surface of the thigh. Sulfanilamide was administered before skeletal traction, open reduction, and the application of a vitallium plate.

*B.* Roentgenogram taken eight months later. All wounds had completely healed.

Since the possibility of infection in a compound fracture is commensurate with the degree of laceration and maceration of the soft tissues, the thirty-five fresh compound fractures were further divided into mild, moderate, or severe. Those compound fractures with small wounds from penetration from within by the bone fragments were regarded as mild. No infection developed, no internal fixation was employed, and in six cases union took place in an average time of three and six-tenths months; in two others sufficient time has not elapsed to secure union. Prior to the discovery of sulfanilamide, one could reasonably expect healing of the wound without infection in this type of compound fracture; consequently, a successful outcome did not necessarily indicate a beneficial prophylactic action of sulfanilamide.

TABLE III

RESULTS OF TREATMENT WITH SULFANILAMIDE OF SEVEN CASES OF OLD COMPOUND FRACTURES WITH LATENT OR POTENTIAL INFECTION

Results	Internal Fixation. No Postoperative Infection		No Fixation. No Postoperative Infection	
	Cases	Average Time	Cases	Average Time
Union . . . . .	3	5 Months	2	3 Months
Too early . . . . .	1		1	
Total . . . . .	4		3	

The group of moderate fractures were those in which the laceration was fairly extensive, incident to protrusion of the bone fragments through the soft tissues, but wherein little or no dirt or foreign material had been introduced into the wound. There were eight of these fractures, in seven of which internal fixation was employed with primary closure of the wound. The average period required for union was two and four-tenths months. Three of the fractures failed to unite, in one of which no internal fixation was employed. One with internal fixation became infected, but the fracture united within one month.

The third group, or severe fresh fractures, consisted of those with extensive lacerations, penetrating wounds from without, considerable extraneous foreign material in the wound, and maceration of the tissues which necessitated extensive débridement. Shotgun wounds, with wadding and bird shot in the soft tissues, might cause such fractures. There were nineteen of this type; internal fixation was applied in nine, and conservative methods were carried out in ten. The results are illustrated in detail in Table II.

TABLE IV

RESULTS OF TREATMENT WITH SULFANILAMIDE OF TWELVE CASES OF COMPOUND FRACTURES WITH ACTIVE INFECTION

Results	Internal Fixation. No Postoperative Infection		No Fixation. No Postoperative Infection	
	Cases	Average Time	Cases	Average Time
Union . . . . .	8	5.3 Months	2	4.5 Months*
Too early . . . . .	2		0	
Totals . . . . .	10*		2	

\* Two bones were plated in one patient, making eleven instances of internal fixation with no infection.



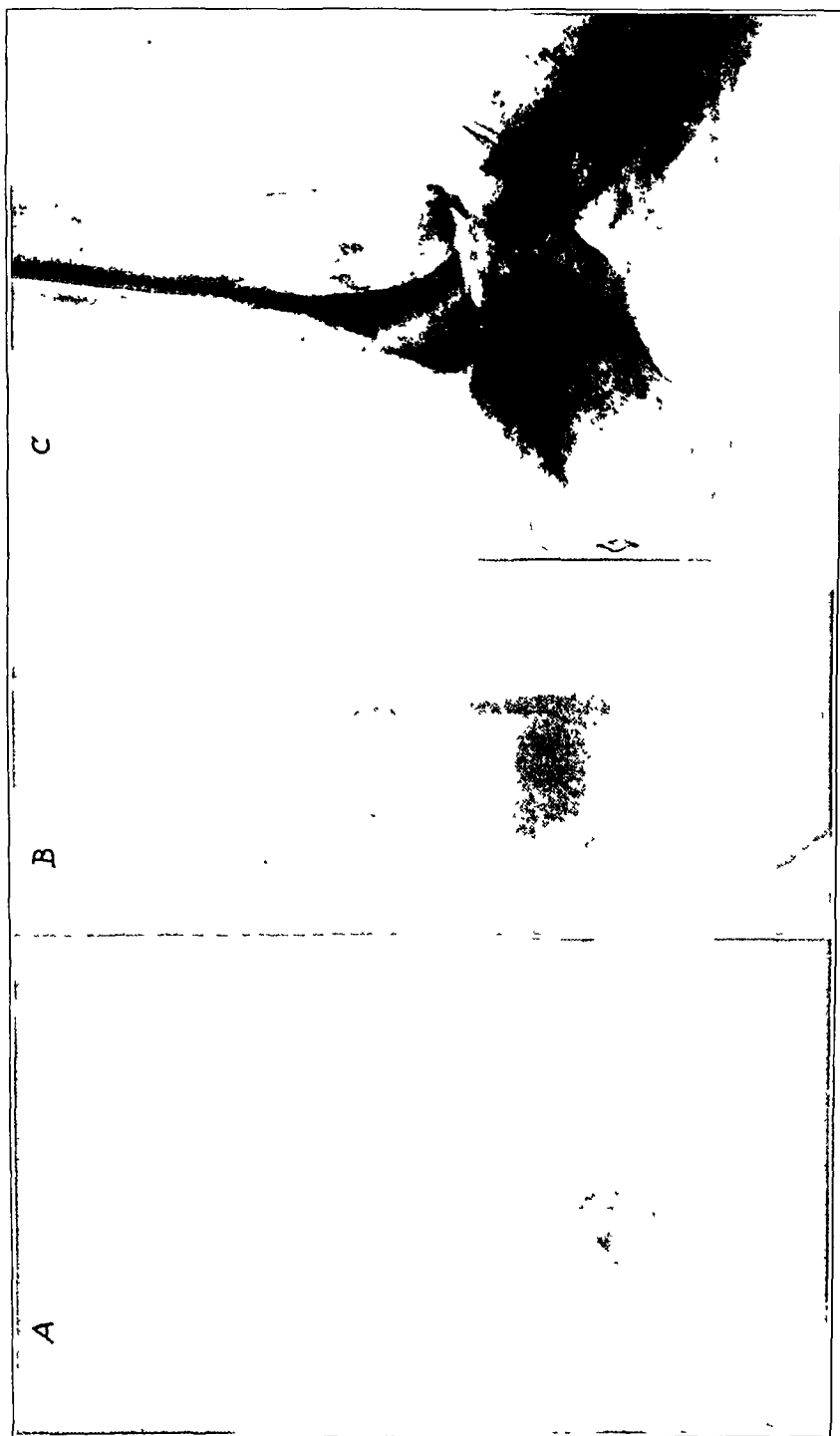


Fig. 8

A. Roentgenogram shows sequestration of astragalus, and loss of both malleoli five months after a compound fracture.  
 B. Roentgenogram taken after astragalectomy in the face of an active infection. Apposition of the surfaces was maintained by a long Steinmann pin placed through the os calcis into the tibia.  
 C. Roentgenogram taken six months later. The wounds had healed in three months. There was no motion in the ankle joint, but it was a satisfactory weight-bearing member.

TABLE V

RESULTS OF MAJOR SURGERY WITH AND WITHOUT SULFANILAMIDE THERAPY  
IN 151 CASES

Results	With Sulfanilamide Therapy				Without Sulfanilamide Therapy			
	Not Infected		Potentially Infected		Not Infected		Potentially Infected	
	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Postoperative infection	1	3 0	3	16.7	3	6 0	5	10.0
No infection	32	97 0	15	83 3	47	94.0	45	90 0
Totals . . .	33	100.0	18	100.0	50	100.0	50	100 0

There was little difference in the average period of union between those with and without fixation. The chief advantage of internal fixation lay in the fact that better anatomical alignment could be secured and maintained, apparently without greater risk of the common complications of delayed union, non-union, or infection. Furthermore, less extensive forms of external immobilization could be employed, enabling the soft-tissue wound to be observed and treated more efficiently without fear of displacing the fragments.

#### COMPOUND FRACTURES WITH LATENT OR POTENTIAL INFECTION

In the seven cases with latent or potential infection, extensive operations were employed,—such as the bone graft for non-union, open reduction and internal fixation for malunion, or reconstruction. In all cases the wounds were closed, and primary healing took place without infection. No control group can be secured from our records, as such radical surgery has not been routinely employed in the past. Often it has been necessary to be content with considerable functional disability, rather than to take the chance of relighting a severe infection with disastrous results.

In three cases internal fixation with vitallium plates was employed; in one, bone grafts were applied with vitallium screws; and in three, no internal fixation was used. Union occurred in five. In two a sufficient length of time has not elapsed to determine the final result. The average period of union in those with internal fixation was five months, while in the two without fixation union took place in three months. This difference may be explained by the fact that more extensive surgery was required for internal fixation, involving an impairment of the circulation secondary to tearing away of the soft tissues.

#### COMPOUND FRACTURES WITH ACTIVE INFECTION

In this group active infection and draining sinuses, often associated with a mild elevation of temperature, had existed for from three to nine

months. In the presence of active infection, open reduction for malposition with delayed union or non-union, with or without internal fixation, might be considered radical. Draining sinuses were dissected out, sequestra and detritus were removed from about the fracture site, and, following replacement of the fragments, the soft tissues were loosely closed. The results are demonstrated by Table IV.

There were no undue or prolonged febrile reactions following operation. In two of the patients a maximum temperature of 103.6 degrees developed, which rapidly subsided; of these, one had previously had a severe staphylococcus aureus infection, and the other had an old extensive draining gunshot fracture. In both of these cases wide soft-tissue dissection was required for internal fixation. Draining sinuses persisted in a number of cases for several weeks to months, but the wounds ultimately closed, and the bones united. In no case was it necessary to remove any of the plates, screws, nails, or wires. The results secured in these fractures with active infection were the most striking of the entire group in which sulfanilamide was administered. Unfortunately, no control group can be secured for a comparative analysis. It is well known, however, that any effort at radical surgery in this type of case is, as a rule, attended by a relighting of a more serious infection, which defeats the purpose of the procedure. It would seem certain that better functional and anatomical results can be secured in a shorter space of time by these new measures than by the previous routine of long delay while the infection heals. With the bones in poor position, subsequent reconstruction operations are necessary.

#### PROPHYLAXIS IN CLEAN AND POTENTIALLY INFECTED SURGICAL CASES

In addition to the use of sulfanilamide in compound fractures, we have employed chemotherapy as a prophylactic preoperative measure to prevent postoperative infections in clean major surgical cases. Although infection develops in only a small percentage of clean cases where careful and efficient technique is employed, the great advantage of a reliable prophylactic measure is obvious. Particularly is this true when reconstruction surgery is employed in potentially infected cases, such as those presenting evidence of a former virulent osteomyelitis. There is no more distressing complication in extensive reconstruction surgery than infection. Any measure, therefore, which would prevent pyogenic infection, even though it is of infrequent occurrence, would be a godsend. In thirty-three major surgical cases attended by excessive trauma, and eighteen potentially infected cases, sulfanilamide crystals were placed in the wounds. Although the favorable results were in some cases of a dramatic nature, we do not believe that definite conclusions can yet be reached regarding this prophylactic treatment. A control group of analogous cases was secured from past records and compared with those in which sulfanilamide was used. Table V shows the findings of this comparative study.

Infections developed postoperatively in 6 per cent. of the control cases in contrast to 3 per cent. of those in which sulfanilamide was administered. Of the potentially infected group, the infection was relighted in 10 per cent. of the control group, and in 17 per cent. of the cases wherein sulfanilamide was employed. Obviously, from these figures sufficient evidence is not present to warrant definite conclusions. Although there were 50 per cent. less infections in the clean surgical cases treated with sulfanilamide than in the potentially infected ones, the evidence presented by the control group apparently is not in favor of treatment or prophylaxis by sulfanilamide. Neither the number of cases nor the type of treatment was analogous, however, since with sulfanilamide more extensive reconstruction surgery was carried out in the face of possible infection than had previously been attempted. Nevertheless, a sufficient number of infections did occur to regard with scepticism the prophylactic benefit of sulfanilamide in this group.

#### CONCLUSIONS

1. The evidence presented does not prove definitely that sulfanilamide either is or is not a preventive of infection in compound fractures. More definite conclusions can be reached only by a comparative analysis of at least 200 cases with a control group of an equal number of analogous cases from past records.

2. Primary healing of mild fresh compound fractures obviously should be disregarded as evidence of any favorable action of sulfanilamide. In the severe and moderate types of compound fractures reported herein, certainly better anatomical and functional results were secured by internal fixation in conjunction with sulfanilamide, without higher proportions of complications, than developed in comparable control groups wherein internal fixation and sulfanilamide were not employed.

3. In seven consecutive cases with potential infection following compound fractures, extensive surgery was followed by more complete restoration of anatomical contour, without relighting of infection, than had been possible in the past.

4. The beneficial influence of this drug was most striking in the group of actively infected fractures in which radical surgery had previously led to disaster.

5. Far too many premature conclusions regarding the beneficial action of bactericidal agents are to be found in the literature. The present impression of sulfanilamide is favorable, but more extensive investigation must be carried out, not only with sulfanilamide, but with other chemotherapeutic agents, before an accurate evaluation is possible.

## AMPUTATION AT THE KNEE JOINT \*

BY S. PERRY ROGERS, M.D., CHICAGO, ILLINOIS

The surgical operation of amputation at the knee joint is a little more than 100 years old. Its first great exponent was Velpeau, who, in 1830, collected fourteen cases and described an operative technique using a circular cuff closed in the sagittal plane. His collection included the first case recorded in America, performed by Nathan Smith in 1824. Steven Smith added ten American cases to the literature in 1852. Markoe added six additional New York cases in 1856, and claimed eight major advantages for the operation, every one of which is pertinent today. Brinton, in 1868, first distinguished between amputation "at the knee-joint" and "at the knee". The latter term embraced all those procedures in which the condyles were cut, and would now include, along with the Carden operation of his day, the osteoplastic operation of Grritti-Stokes and the tendoplastic operation of Callander. Otis collected 211 knee amputations from the records of the Union Army in the War between the States and found a mortality rate much more favorable than that in amputation through the thigh. Watson published a book on amputations in 1885, praising this site of election and quoting a number of distinguished contemporaries of the same opinion. The terms "disarticulation", "ex-articulation", and "amputation in contiguity" were used to describe "amputation at the knee-joint".

During the past fifty years this site has fallen into neglect and disrepute. It was little used in the World War of twenty-five years ago. Philip Wilson, Huard, Kurts and Hand, Eloesser, and Lee have condemned it within the past decade. The latest handbook of the Association of Artificial Limb Manufacturers of America, dismisses the site as "impeding to successful prosthesis". Two reasons for its decline in the latter part of the past century are negative reasons. With the use of anaesthesia the saving in time seemed less important, and with the advent of asepsis the danger of opening bone marrow and muscle bellies to infection was ignored. Many recent objections have been founded on concern for the leg-maker. The opinion current among surgeons, that an efficient and sightly prosthesis cannot be made for this amputation, is, however, no longer grounded in fact. Other recent objections founded on case reports of tenderness over the "floating" patella and of late atrophy and ulceration over the condyles are explained by fundamental faults in the operation as heretofore performed. Two essential steps in the operation to be described are designed to prevent these two complications.

The author's approach to this problem has been functional, the object

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being to create a stump which would function in a manner as nearly like the normal lower extremity as possible.

The primary function is weight-bearing, and the secondary function is locomotion, both of which depend on the relative absence of pain. The only tissues normally subjected to outside pressure are: finely trabeculated cancellous bone, surrounded by a thin cortex, and covered by either hyaline cartilage or adherent periosteum; the tendinous origins or insertions of muscles; secretory pouches such as joint cavities and bursae; areolar connective tissue; and skin—the last two of a congenitally specialized variety. The bellies of muscles and the cortical shafts of long bones are nowhere subjected to pressure. Weight-bearing, opposed to the vertical force of gravity, demands a horizontal body surface, and the larger this horizontal area is, the less pressure is required per unit of surface. Requisite for locomotion is the preservation of the function of muscles remaining in the stump by retaining their natural length and their origins and insertions to bone. Locomotion in a stump demands effective

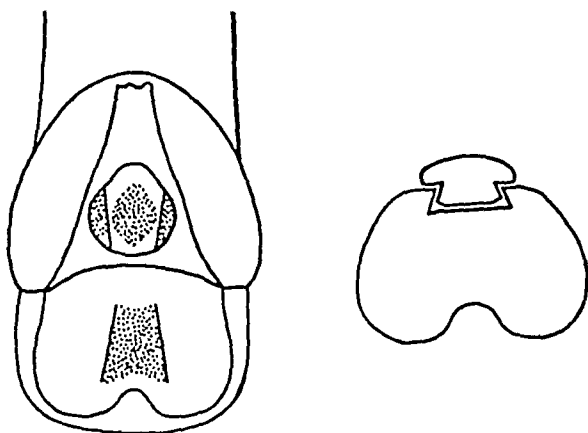


FIG. 1

Diagram of fixation of patella by dovetail mortise. Left sketch shows anterior flap turned up *en masse*, patella dovetailed by undercutting its edges into wedge shape wider at the lower pole (cephalad), mortise undercut into front of femur in wedge shape wider at bottom. Right sketch shows horizontal section of completed dovetail mortise.

motor leverage and lateral surfaces capable of transmitting such force to a prosthesis. Finally, a prosthesis must be turned and lifted as well as propelled.

The following technique for amputation at the knee joint includes three essential features: creation of a terminal flap from tissues normally subjected to external pressure; fixation of the patella to the front of the femur at a level serving to increase the horizontal end-bearing surface area; and suture of the hamstring tendons to the tip of the patellar tendon in the posterior intercondylar notch. The operating room set-up described by Callander is recommended,—that is, the patient supine, the knee flexed, and the operator on the side opposite the extremity. It allows easy access to the popliteal space through the cleft between the adductor longus and the inner hamstrings. A tourniquet may be omitted. A broad anterior flap extends one inch below the tibial tubercle, and a broad posterior flap one inch below the flexion crease. The length of the flaps depends somewhat on the obesity of the patient and on the healthy tissues available; the object is to cover the condyles snugly. Retraction

of muscles and the consequent need for excessive length of flaps are avoided by attaching all tendons to bone.

Deep dissection proceeds from the inner side first. The tendons of the four inner hamstrings are exposed in order, identified with Allis forceps, and cut low down. The popliteal artery is now accessible, and is ligated just below its superior geniculate branches. The tibial nerve is ligated, injected with alcohol, and cut. The common peroneal nerve may be dealt with in a similar manner at this time or reached from the outer side later. The outlines of the anterior flap are carried through the deep fascia and reflected *en masse*. The patellar tendon is freed as close to the tubercle as possible. Skin, fascia, patellar tendon, and synovial membrane are reflected in one undisturbed full thickness. The tendon of the biceps femoris and the iliotibial band are identified with Allis forceps, and cut low down. The short posterior flap is reflected upward; the lateral and crucial ligaments are cut close to the femur; and the leg is separated from the thigh by stripping the heads of the calf muscles from the femur.

Function of all of the muscles motivating the thigh is preserved by attaching all of the tendons under normal tension to the end of the stump. The patellar tendon reaches well back into the intercondylar notch, and may simply be sutured to the ends of the hamstring tendons in that location. However, fixation of the patella to the front of the femur, with its lower pole on a level horizontal with the lower surfaces of the condyles, serves to increase further the size of the horizontal end-bearing surface. To accomplish this fixation a dovetail mortise is recommended, the patellar dovetail being slid up from below and retained by the tension of the quadriceps. As an alternative procedure, the apposing cartilaginous surfaces may be denuded, and the patella fixed with a vitallium nail. The ends of the hamstring tendons, still identified by forceps, are next

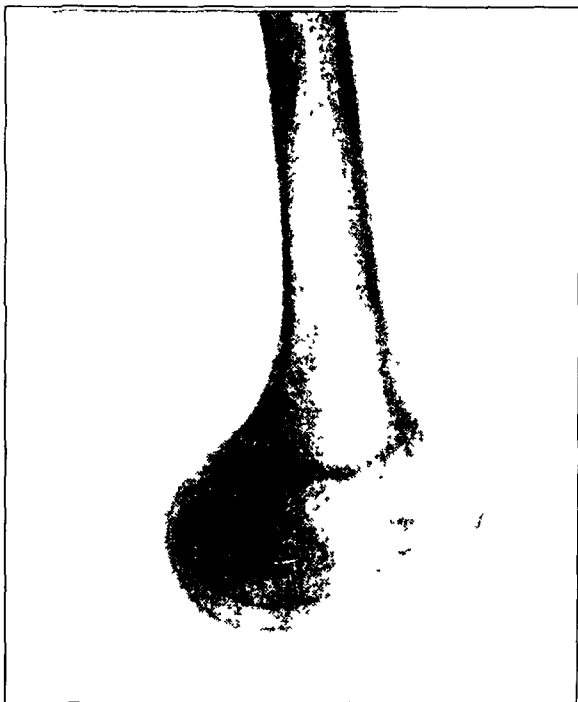


FIG. 2

Lateral roentgenogram of stump, showing patella fused to front of femur, its lower pole forming a third point of bony support in the same horizontal plane with the lower surfaces of the condyles.



FIG. 3

Photograph of stump after one year of function in prosthesis. Note minimum degree of muscular atrophy. Also note triangular and bulbous shape of tip, which is useful in lifting the prosthesis and in controlling its rotation.

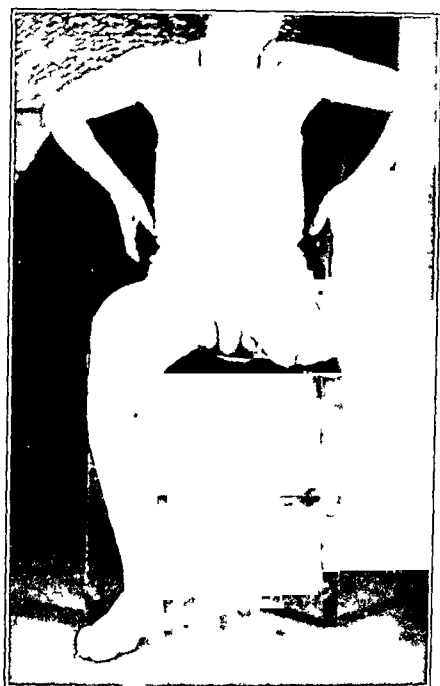


FIG. 4

End of stump after one year of function. Note size of end-bearing surface area supported by three bony prominences, and composed of tissues adapted to pressure.

securely sutured to the tip of the patellar tendon. The biceps and three of the inner hamstrings may be so secured, while the sartorius and the iliotibial band may be conveniently sutured to the fascial layer of the edges of the anterior flap.

No excision of synovial membrane, or denudation of synovial cartilage is performed, and no drains are necessary. The flaps are trimmed to fit snugly, and the fascial layers are closed with interrupted catgut, and the skin with interrupted silk. Dry gauze dressings are applied, and a simple pressure pad over the end of the stump is attached by four strips of adhesive tape to the skin of the thigh. No cradle is used to protect the stump from the weight of bedclothes. Pressure exercises, such as stepping on a padded chair, may be started two weeks after operation, and within six weeks the stump should be ready for walking in a permanent prosthesis. A pylon is not recommended.

This amputation presents surgical advantages recognized a century ago and still sound. The avoidance of cutting through bone makes the operation easy and rapid; minimizes surgical shock; and avoids both opening medullary bone to infection, and stirring up fat embolism. By not severing any muscles in their fleshy bellies, paths for infection are not opened up within their sheaths. The resulting stump fulfills the requirements for function in the following ways:





FIG. 5

Prosthesis applied. Note leather socket padded at the bottom, entered at the front, and laced up like a shoe. Elastic harness from pelvic girdle replaces action of quadriceps muscle in extending knee.



FIG. 6

Prosthesis applied, patient sitting. Note that limb is *not* undesirably bulky about the knee, and that the thigh does *not* appear longer than its fellow.

1. It provides the largest horizontal end-bearing surface area available in the lower extremity.
2. The bone, soft tissues, and skin at the end of the stump were all previously adapted to weight-bearing.
3. The terminal integuments subjected to pressure are not subjected to tension.
4. Muscular control of the stump is achieved by preserving the length and attachment of every muscle motivating the thigh.
5. Excellent leverage can be exerted on a prosthesis because the stump is long and because its terminal circumference is both firm and insensitive.
6. The triangular tip, composed of patella and two condyles, assures control of rotation of the prosthesis.
7. The bulbous shape of the tip allows the stump to lift a prosthesis as the foot lifts a shoe.
8. Atrophy is minimized by preserving the function of most of the muscles left in the stump, and by the early use of a permanent prosthesis.

9. Vascularity of the terminal tissues is unexcelled. Ligation of the popliteal artery below its superior geniculate branches leaves the richest system of arterial anastomoses available in the extremity. The greater part of the terminal flap comes from in front of the joint space and therefore already has a blood supply independent of its underlying tissues.

10. Preservation of the lower femoral epiphysis, accountable for 90 per cent. of growth of the femur, allows normal development of the stump following amputation in childhood.

The prosthesis suitable for this amputation must meet certain specifications. The socket should fit the stump snugly to within two inches of the perineum, with allowance for one inch of felt in the bottom of the socket. The diameter of the stump is greater at the condyles than immediately above them; therefore the socket must be entered from the front and laced up like a shoe. The lower third of the socket should be rigid, to prevent the sides from squeezing together when pressure is exerted on the bottom. Side joints must be used, to equalize the lengths of thigh and leg. The prosthesis may be used without harness, but elastic straps from a simple pelvic girdle to the outer side of the thigh socket and to the front of the shin piece serve to increase stability and to quicken the step.

Summaries of twenty-three amputations in twenty-two patients are available for analysis. For twenty operations the author is directly or indirectly responsible. In seven of these the technique described was followed exactly, and in the remainder it included at least two of the three steps indicated as essential. All were performed between April 1933 and November 1939. The ages of the patients ranged from six to seventy-three years; eight were under twenty and four were past sixty. Analysis of the causes for amputation shows a preponderance of operations performed for the relief of chronic disability. Only four were primary amputations following severe trauma. One was for osteogenic sarcoma of the tibia. Five were necessitated by vascular disease; two for arteriosclerotic gangrene, and one each for thrombo-angiitis obliterans, diabetic gangrene, and polycythaemia vera. Thirteen were done to relieve patients of hopeless deformity, congenital or post-traumatic, or of intractable bone infection. Four were reamputations.

There was one death in the series,—a forty-year-old man, whose stump had healed by primary intention, died of streptococcus septicaemia eight days after his second reamputation for chronic osteomyelitis. Minor sloughs occurred in three suture lines,—in two because the flaps were cut too short in obese patients, and in the other because of old scar tissue in the flaps. Late complications of a minor nature developed in three cases. Ulceration over one of the condyles developed in one case because of old scar tissue previously deprived of its sensory nerve supply, and in another case in which the hamstring tendons were not anchored. Recurrent tenderness over the patella developed in one case in which the patella was not anchored. Excluding the one death and two elderly patients oper-

ated on less than three months ago, every one of the remaining nineteen patients has been able to use a prosthesis successfully. Eight used pylons for short periods. Five walked on some kind of prosthesis one month after amputation, and five more used prostheses within two months. The problem has been to obtain artificial limbs rapidly enough, rather than to prepare the stumps for their use. One patient does manual labor on bilateral prostheses. Another patient, with a satisfactory amputation on the opposite side at the recognized site of election in the leg, considers the side amputated at the knee joint his more serviceable extremity. In all cases more than six months old, three-fourths of the patients have returned to occupations as strenuous or more strenuous than those pursued previous to amputation. All the six patients under fifteen years of age have demonstrated continued growth of their stumps without atrophy or ulceration of the terminal integuments.

The author is grateful for the contribution of one or more cases to this series by each of the following surgeons: Toufick Nicola, Paul C. Colonna, George J. Garceau, Ralph M. Carter, Claude N. Lambert, Frank G. Murphy, Walter R. Fischer, and Will F. Lyon.

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# INJURY TO INTERVERTEBRAL DISCS DURING SPINAL PUNCTURE

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Routine diagnostic spinal puncture is generally regarded as a rather innocuous, though moderately uncomfortable, procedure, and probably is, in the vast majority of cases. Considering the number of punctures performed annually by individuals of varying experience and skill, and the paucity of reported complications incident thereto, one is led to believe that spinal tapping is indeed relatively free from danger. Occasionally local accidents, such as the breaking of a needle after entry, are worrisome. The advent of any degree of infection is always a perilous sequel. So-called dry and bloody taps are usually ascribed to ineptness on the part of the operator,—and promptly forgotten. Yet, according to Pease, even following a successful puncture, many people complain of pain in the lower back and little significance is attached to the origin of this complaint. It is dismissed as a necessary inconvenience.

As a matter of fact, Pease, in performing lumbar punctures on cadavera, learned that he could not always determine when the point of the needle was actually in the neural canal or past it, even when it struck the intervertebral disc and penetrated it (Fig. 1). Experimentally he found that the most common sites for the final landing-place of the instrument when pushed beyond the neural canal were: (a) intervertebral discs, (b) vertebrae, (c) interarticular facets, and (d) venous sinusoids in the vertebral body. Levinson listed as one of the causes of a dry tap, introduction of the needle so far beyond the spinal canal that the intervertebral disc was punctured and the needle clogged with nuclear material exuding therefrom. This obviously injures the structure of the disc. This fact is to be borne in mind in evaluating the case that is herewith reported.

Keyes and Compere proved that: (1) if the cartilaginous plate of the intervertebral disc of the dog is injured by a scalpel or drill, the nuclear material prolapses into the spongiosa of the vertebral body, and a cartilaginous nodule forms; and (2) if nuclear material is allowed to escape, the rest of the disc becomes thinned out and the edges of the adjacent vertebrae become sclerosed with subsequent marginal lipping. This work gives support to the findings observed in this case, and those of Milward and Grout. These authors reported five cases of back trouble starting from within a few moments to six months following spinal anaesthesia. Roentgenographic investigation revealed progressive arthritis localized in one intervertebral joint, loss of joint space, and new bone formation linking up articular edges of the bodies of adjacent vertebrae. Pease in 1935

presented three cases of intervertebral-disc injury following lumbar puncture with convincing clinical, roentgenographic, and experimental evidence to support the views that appear in his article.

Geist, Calvé and Galland, Sashin, and Beadle have enumerated a number of pathological conditions in which the intervertebral nucleus pulposus is either primarily or secondarily involved. Keyes and Compere in a comprehensive paper have elected to classify the various lesions according to the primary location of the pathological process, but admit it is obvious that there must be some overlapping, in the following three groups: (1) pathological conditions of the nucleus pulposus; (2) pathological conditions of the cartilage plates; (3) pathological conditions of the vertebral bodies.

Although these three main groups are further subdivided into eleven sections, each briefly discussed, no mention is made of the injudicious use of the spinal puncture needle as a possible cause of acute trauma to the components of the intervertebral disc. Compere, however, in discussing Pease's paper on this subject, admitted that such a situation is by no means inconceivable.

The following case is presented in the belief that it is one in which the second and fourth lumbar intervertebral discs were traumatized during spinal puncture in a manner analogous to the experimental injuries described by Keyes and Compere. Similar resultant pathological changes in the vertebrae are revealed by comparative roentgenograms over a period of many months.

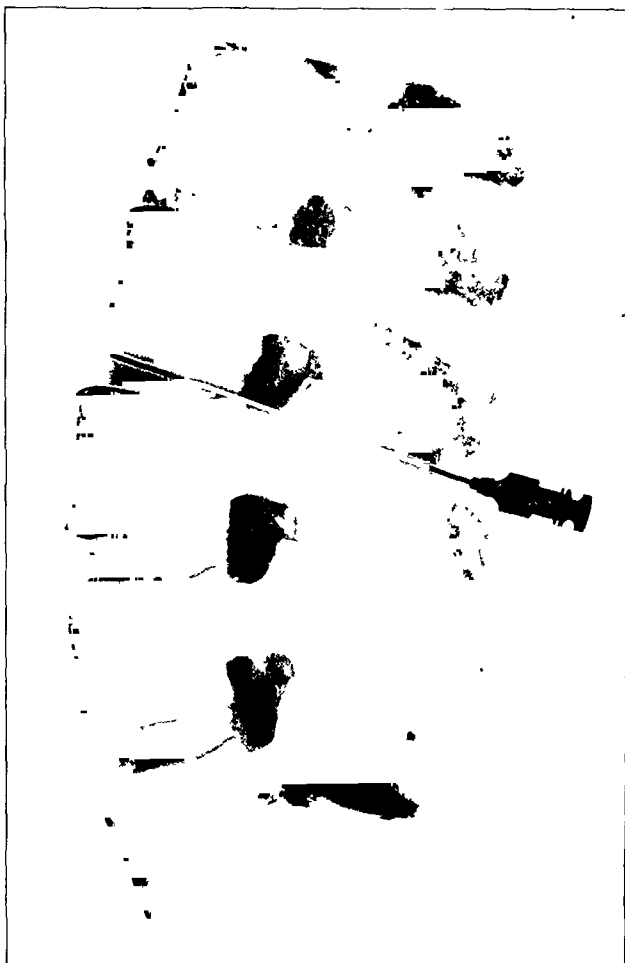


FIG. 1

Roentgenogram. Dr. Louis J. Kolodner has demonstrated on a cadaver the ease with which a spinal-puncture needle may be inserted directly into the intervertebral disc.

## CASE HISTORY

D. S., a fourteen-year-old white girl, has been known to the Sinai Hospital Out-Patient Department since October 4, 1932, when, at the age of seven, she was brought there for a complete examination. Her father had died at thirty-three of general paresis, and her mother and brother were being treated for general paresis and congenital syphilis, respectively. The past history indicated that when the girl was nine months of age, she had convulsive seizures which terminated in a right-sided hemiparesis. This gradually, though not completely, cleared during her early childhood.

The patient received adequate antiluetic treatment while under observation. On June 20, 1936, a routine spinal puncture was performed without any difficulty. Her first admission to the hospital was on July 7, 1936. Between this date and August 16, 1936, she successfully and satisfactorily weathered ten paroxysms of induced tertian malarial fever. She was, thereafter, again followed in the dispensary.

On September 4, 1937, three fruitless attempts at spinal puncture at several lumbar levels resulted in an immediate and continuing complaint of local pain which was severe enough for the next few weeks to make her spend most of her time in bed, except when she was transported to and from the clinic. On September 8, 1937, x-rays were taken and read as negative (Fig. 2). As home rest proved ineffective, she was admitted to the hospital on September 27, 1937.

When first seen in the ward, the child was apparently in so much discomfort that a satisfactory examination could not be made. The lumbar spine was held in a position of marked hyperextension. The slightest passive movement of the head, neck, or lower extremities was sufficient to provoke additional spasm and pain. There were a number of pin-point puncture wounds in the skin of the lumbar region.

The known history that a previous spinal tap had not been followed by such severe complaints naturally led to the suggestion that there was a direct causal relationship between the dry taps and the immediate response in the lower back. Since it was noted within a few days that the temperature was elevated to 101.2 degrees, local infection of the epidural tissues was considered as a diagnostic possibility along with traumatic periostitis and intervertebral-disc pathology.

Under rest on a Bradford frame and mild sedation the child became more tractable. A more complete physical examination revealed a right-sided ankle clonus and a suggestive positive Babinski response which were regarded by Dr. I. J. Spear as residual evidences of the old aforementioned cerebral affection at nine months of age.

Within one week the local pain subsided and the extreme lumbar lordosis slowly receded, the spine assuming its natural contour. A convex frame was then employed, but in spite of this form of support and enforced recumbency, on October 13, 1937, about five weeks after the puncture, prominence of several lumbar spinous processes was noted. Gradually there developed a general posterior bowing of the lumbar spine with a noticeable kyphos at the level of the second and fourth lumbar vertebrae. On October 22, 1937, an uneventful spinal puncture was made. The total proteins were within normal limits, the Wassermann reaction was still positive, and the colloidal gold test showed activity in the paretic zone. No trouble, such as had followed the tap of September 4, 1937, was encountered. On November 1, 1937, a plaster jacket was applied with the lumbar spine in extension. This was later replaced by a spinal corset which was worn for more than a year. When this was finally removed, no local symptoms were noted. The back moved freely but the knuckles at the second and fourth lumbar spinous processes were still present with no appreciable increase in size.

A series of roentgenograms taken at varying intervals from September 8, 1937, four days after the onset of difficulties, to April 27, 1939, a period of nineteen and one-half months, demonstrated the changes that took place in the intervertebral discs and the adjoining structures.

The first set on September 8, 1937 (Fig. 2), as mentioned, were negative for any significant changes. Those on October 5, 1937 (Fig. 3), one month after the puncture,

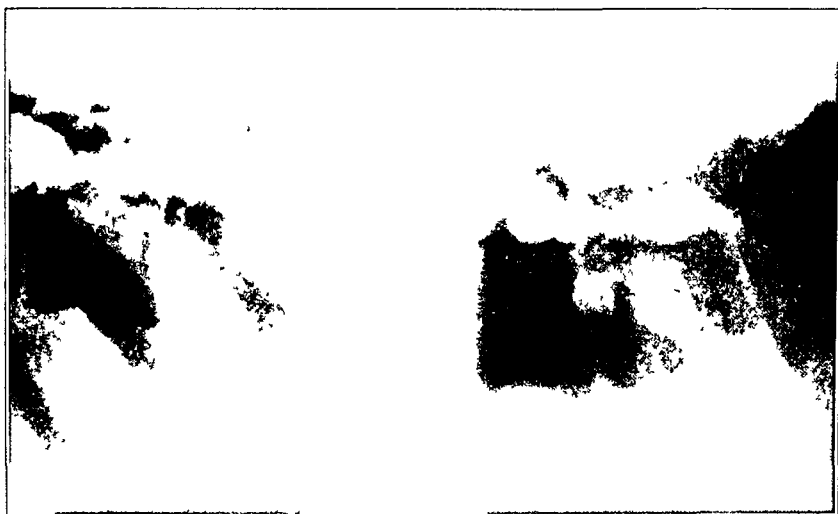


FIG. 4

Roentgenogram, April 27, 1939, taken over a year and a half after spinal puncture, shows irregularly circular, punched-out areas, surrounded by a zone of sclerosis in the bodies of the first, second, third, and fourth lumbar vertebrae.

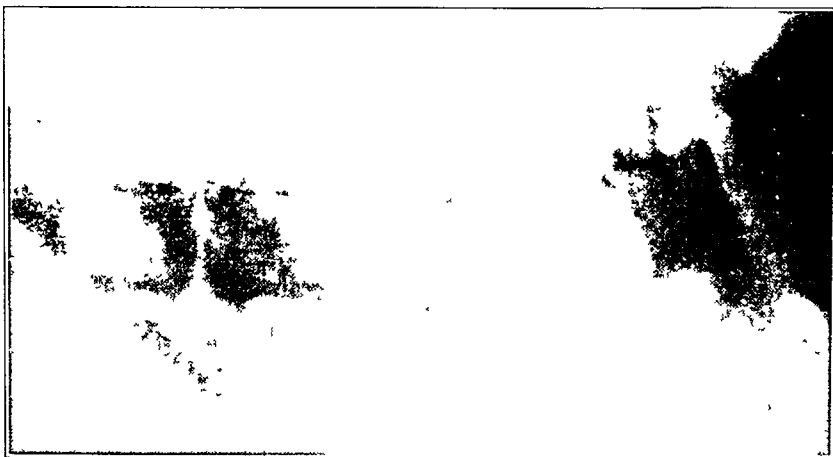


FIG. 3

Roentgenogram, October 5, 1937, one month after spinal puncture, shows widening of the intervertebral spaces between the second and third, and fourth and fifth lumbar vertebrae; narrowing of the space between the third and fourth lumbar vertebrae; and roughening of the inferior border of the body of the third lumbar vertebra.



FIG. 2

Roentgenogram, September 8, 1937, four days after spinal puncture shows no demonstrable defect. (Dark area at anterior-inferior portion of the body of the fourth lumbar vertebra is gas.)

showed a suspicious narrowing and roughening of the joint space between the third and fourth lumbar vertebrae with a relative widening of the spaces between the second and third, and fourth and fifth lumbar vertebrae. On May 26, 1938, eight and one-half months after the onset, the first demonstrable defects were noted in the adjacent margins of the bodies of the first and second, and third and fourth lumbar vertebrae. These defects, easily visible in all subsequent x-rays until the last, taken on April 27, 1939 (Fig. 4), have remained unchanged in shape, structure, and location, and stereoscopically represent small, irregularly circular, punched-out areas surrounded by a zone of sclerotic bone.

It is felt that the defects shown in the roentgenograms of this case are so-called "Schmorl bodies". Similar areas, when subjected to pathological section, have proved to be a cartilaginous ingrowth from the disc structure to the substance of the vertebral body. These areas were described by Schmorl in 1937 when he reported that 37 per cent. of 7,000 spines which he routinely sectioned showed prolapses of disc material into the spongiosa of the adjacent vertebral bodies.

Pease in his paper referred to the anatomy of the intervertebral unit as consisting of (a) superior and inferior cartilaginous plates, (b) the annulus fibrosus, and (c) nucleus pulposus. The annulus fibrosus is thicker anteriorly than posteriorly. This difference, together with the close union with the anterior longitudinal ligament, makes the disc much stronger and more powerful in front. The nucleus pulposus is a translucent, semigelatinous fluid under considerable pressure, through which are interspersed fine fibrous strands. This fluid occupies considerably more volume in the young, and gradually becomes more firm and solid with advancing age. On flexion (the position assumed during spinal tapping of the spine) the pressure within the disc increases as the anterior portions of the bodies come in closer approximation, causing a slight bulge of the disc and its nuclear material posteriorly. A needle puncturing the nuclear portion of this disc permits the material to escape. Pease has clearly demonstrated this on cadavera, and shown by roentgenograms, taken before and after deliberate introduction of a needle into the disc, a definite narrowing of the disc and intervertebral space, with a compensatory widening of the neighboring spaces. When this nuclear material is extruded through a crack, or other defect in the cartilage plate, into the spongiosa of the vertebral body, an invasive reaction is set up in the bone. The semifluid material is transformed into a cartilaginous nodule (Schmorl body), and the bone about it becomes sclerosed, forming a secondary line of defense to wall off the foreign material. Until sufficient time has elapsed following the prolapse of the nuclear material of the disc for the reaction in the bone to take place, roentgenographic diagnosis usually cannot be made. When the nuclear material is allowed to escape, but does not percolate into the adjoining vertebral body, the rest of the disc becomes thinned out and the margins of the adjacent vertebrae become sclerosed with subsequent marginal lipping.

It is believed that in this particular instance the plates demonstrate (1) narrowing of the joint space (Fig. 3), (2) compensatory widening of the



adjoining spaces (Fig. 3), and (3) Schmorl bodies (Fig. 4). Late sclerosis and marginal lipping of the vertebral bodies have as yet not developed.

#### SUMMARY

Herewith is presented the case of a syphilitic girl, aged fourteen, whose spine was first punctured on June 20, 1936, without any untoward effects. On September 4, 1937, she was subjected to several unsuccessful spinal taps. These were followed by immediate clinical manifestations of some local disturbance at the site of these taps. Lumbar hyperextension and severe pain were replaced within five weeks by lumbar flexion and prominence of the spinous processes of the second and fourth lumbar vertebrae. Roentgenograms on September 8, 1937, were read as negative for bone pathology, but, as time went on, subsequent plates from October 1937, until the final date of observation in April 1939, gave evidence of narrowing of the affected joint spaces, compensatory widening of the adjacent joint spaces, and the development of the characteristic inter-articular, intra-osseous Schmorl's nodules which are generally regarded as pathognomonic of intervertebral-disc disturbance. The entire succession of events in this case is so direct and clear that it is difficult to escape the conclusion that the described end results followed the misadventurous spinal puncture.

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# HYDATID CYST OF THE BONE

## A CASE REPORT

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Hydatid cysts have been described by medical writers since the earliest times. The character of the growth was determined in 1782 by Goeze<sup>6</sup> who noted the similarity between the microscopic projections from the inner surface of the cyst and the heads or scolices of the adult tapeworms of the *Taenia* group. He established the fact that the growth was the larval form of a cestode which he named *Taenia granulosa*.

The adult is a tapeworm 3 to 6 millimeters long which inhabits the small intestines of several animals, most frequently of the dog. Viable eggs, passed in the feces, are easily transferred to other animals. Almost any mammal can be infected by the ingestion of the ova. The eggs hatch in the duodenum or jejunum of this intermediate host. The larvae migrate through the intestinal wall, enter the venules, and are carried along by the blood. Many of these larvae become caught in the capillary filters where they develop into hydatid cysts (Fig. 1).

Experimental investigation by Dew<sup>2</sup> has shown that there is an immediate cellular response to the presence of the larva. During the two weeks following infection the parasite becomes encysted in a cavity usually filled with a clear fluid. Three zones can be distinguished in the wall: on the inner surface the parasite is surrounded by endothelial cells with an occasional giant cell and eosinophils arranged somewhat radially; around this is found a concentric layer of fibroblasts and leukocytic cells; and peripherally there is a zone of degenerated cells of the host tissue which grades into the normal substance. As growth continues the pressure causes the outer layers to become laminated. From the inner wall, the portion infective for the definitive host, brood capsules arise which in turn produce the scolices.

In the case of hydatid cyst of the bone, the parasite has only a partial envelope. With the growth of the larva, pressure on and occlusion of the small arteries finally bring about necrosis. This leads to the breaking down of the bone, and the formation of caseous debris. As this continues, local weakening of the bone occurs, and often results in spontaneous

## Life History of *Echinococcus granulosus* (diagrammatic)

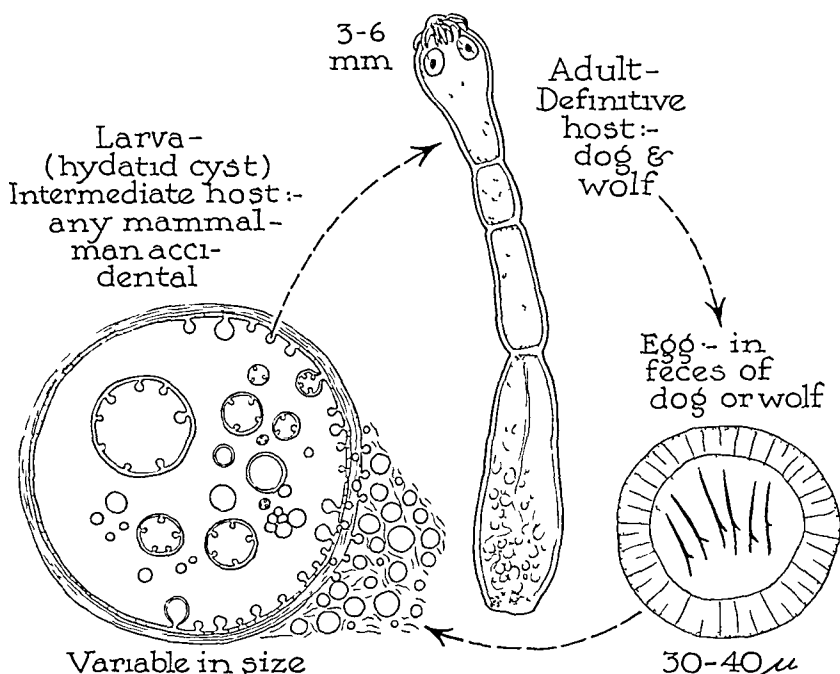


FIG. 1

Diagrammatic representation of life history of *Echinococcus granulosus*. Eggs produced by the adult worm are passed in the feces of the definitive host. These enter the intermediate host in contaminated food or water. The eggs hatch and the larvae pass to various parts of the body where they develop into hydatid cysts which vary in size from a few millimeters to 15 centimeters or more in diameter. (Adapted from drawings by Prof. E. C. Faust in Human Helminthology, Philadelphia, Lea & Febiger, 1929)

fracture. A complete discussion of the manner in which the hydatid cysts affect the bone can be found in the work of P. Larghero-Ibarz<sup>9</sup> and Oscar Ivanissevich<sup>7</sup>. According to Dew<sup>4</sup>, 76.6 per cent of human echinococcus infections are found in the liver, the first filter encountered. The larvae may pass this barrier and be stopped by the lungs, but, carried beyond this filter, they may enter any organ or tissue of the body. The bones are invaded in .9 per cent of the cases.

Something over 480 cases of echinococcus disease have been reported from the United States, nineteen of which were infected in this country. Magath<sup>10</sup> suggested that the others were brought in as "unseen baggage" by immigrants from countries where the disease was endemic. Of all the cases reported, five were echinococcus infection of the bone: Woods<sup>14</sup>; Walker and Cummins<sup>13</sup>; Stone<sup>12</sup>; and Coley<sup>1</sup> (two cases). This is a report of an additional case. The birth place of the sailor described by Woods<sup>14</sup> was not mentioned. All the other patients, including the one under discussion, were born in countries where the disease is prevalent.

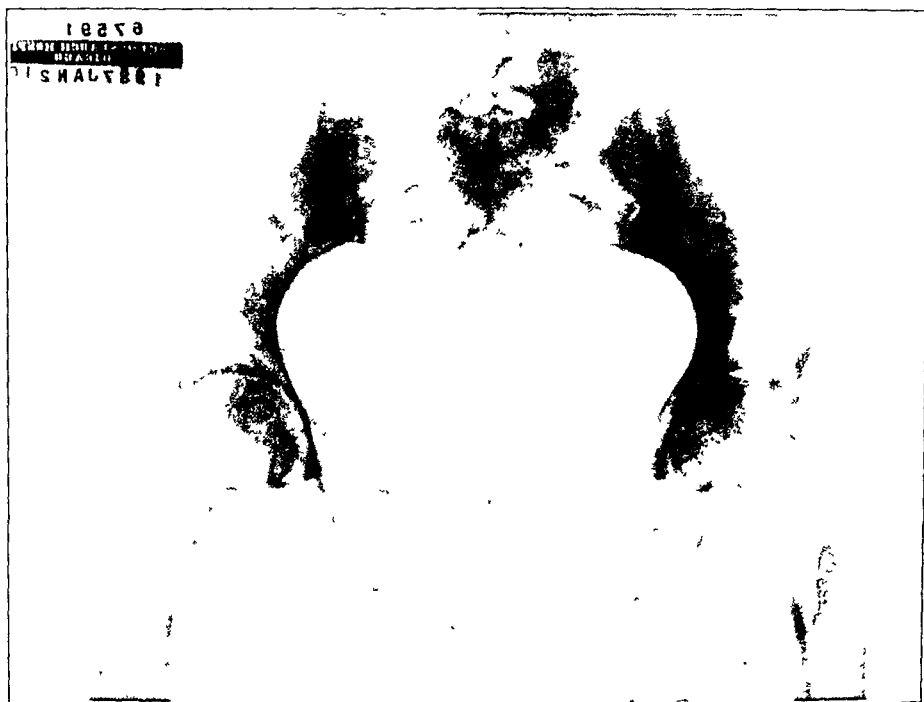


FIG. 2

Roentgenogram taken on admission to the Dispensary, January 21, 1937.

#### CASE HISTORY

A Polish housewife, fifty-five years of age, was transferred from the Surgery Department to the Orthopaedic Dispensary on January 21, 1937. Her chief complaint on entrance was pain in the left hip. The history elicited the fact that in September, 1936, she had fallen on a waxed floor and injured her left hip. A roentgenographic examination made at this time was reported negative. After six weeks in bed she was able to walk, but was limited in her activity by severe pain in the region of the ilium.

On December 31, 1936, she again fell, this time injuring the same region to such an extent that she was compelled to remain in bed, until January 21, 1937, when she came to the Dispensary. The Dispensary physician, finding pain on motion in all directions of the hip joint, made a tentative diagnosis of arthritis.

*Roentgenographic Findings:* Figure 2 was taken at the time of admission to the Dispensary. The x-ray made of the pelvis in the anteroposterior direction showed irregular decalcification involving most of the left ilium. It extended upward from the acetabulum to the crest, limited medially by a narrow zone of normal bone with an irregular line of demarcation. Several linear radiolucent areas extended through it which suggested pathological fractures. Coarse trabeculation in the region of the anterosuperior spine suggested giant-cell tumor as the primary lesion, but sarcoma, metastatic malignancy, and myeloma deserved consideration in differential diagnosis. (Practically the same possibilities are suggested by Faust<sup>5</sup> in his discussion of the diagnosis of hydatids of the bone.) The patient was admitted to the hospital primarily for biopsy.

*Operative Findings:* An exploratory operation of the left ilium was performed on February 4, 1937. A Smith-Peterson incision was made. After the skin had been reflected, a bulging mass appeared in the subcutaneous fat tissue. As this was cut, an appreciable amount of yellow, frothy material gushed out which looked like vaseline that had been mixed with air. When the opening was enlarged, a cystic cavity about two inches in diameter was disclosed which extended through both tables of the ilium.

More of this yellow material was found in this pocket. After a large-sized piece of bone had been removed, the cavity was seen to extend downward and anteriorly into the roof of the acetabulum and the pubic ramus. The material taken from this region was very different in character. Here were found many small gray-white, definitely circumscribed, cystic masses ranging from 5 to 15 centimeters in diameter. These small bodies were stuck together with a mucilaginous substance. As far as was possible all these cysts were removed (Fig 3), but undoubtedly some were left in recessed pockets.

The fracture seen in the roentgenogram made the whole crest of the ilium freely movable. It was not considered advisable to dissect more of this material or sacrifice more of the ilium until a positive diagnosis was made. The wound was closed in layers, and a dry dressing applied. Because of the weakness of the acetabular roof, the leg was placed in traction and kept so for four weeks.

*Subsequent Care:* The wound healed by primary union. Some pain persisted on motion of the hip joint and on weight-bearing, so the patient was cautioned not to walk without the aid of crutches. The patient has returned to the Dispensary about every two months for observation. Roentgenograms have been taken at various times, the latest (Fig 4) on April 14, 1939.

She was last seen in the Dispensary on October 11, 1939, at which time she was walking without crutches, but showed a rather marked limp. The pain in her hip was not severe though annoying when she remained standing for any length of time.

*Laboratory Findings:* Gross examination of the material removed warranted a tentative diagnosis of hydatid cyst. For confirmation, the fluid from some of the cysts

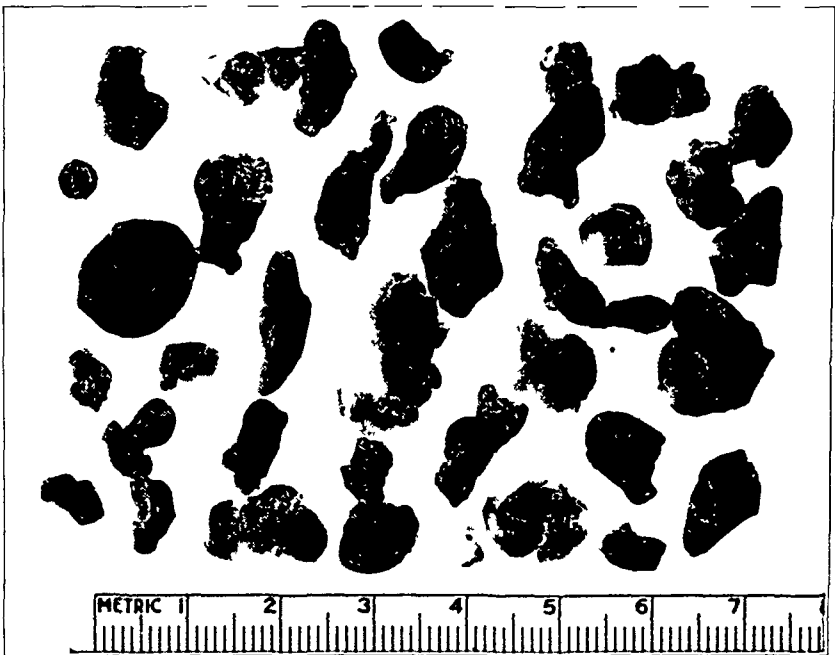


FIG. 3

Hydatid cysts removed during operation on February 4, 1937.

was examined for scolices or hooklets. None were found. (Dew<sup>2</sup> stated that most hydatid cysts of the bone are unproductive of scolices until they reach a cavity large enough for the accumulation of considerable fluid.)

Histological sections of several cyst walls were made. These showed an inner surface of epithelium with certain areas surrounded by fibrous tissue, some of which



FIG. 4

Roentgenogram taken two years after operation, April 14, 1939.

showed concentric ring formation. This constitutes the poorly formed, outer, laminated layer, characteristic of osseous hydatid cysts.

A complement-fixation test gave a reaction of two plus. (Kellaway and Fairley<sup>3</sup> reported that 50 to 60 per cent. of hydatid cyst cases give a positive complement-fixation reaction before the first operation. A reaction of either one plus or two plus is specific and diagnostic. If the reaction is still positive nine months after operation, secondary cysts are undoubtedly developing.)

A Casoni test or skin-sensitivity reaction was also carried out. This was done more for general interest than for need of further confirmation of the diagnosis. Sheep-hydatid fluid was obtained from the United States Meat Inspection Department. This was filtered, and .2 cubic centimeters injected intracutaneously. An oedematous area about the point of injection reached its maximum of 7 centimeters at the end of two hours. This was surrounded by a 4-centimeter area of erythema. Controls made with both saline and normal sheep serum were essentially negative. (According to Kellaway and Fairley<sup>3</sup> 75 per cent. of patients with hydatids give a positive skin reaction preoperatively. This reaction persists for years.)

#### DISCUSSION

The development of all hydatid cysts is a slow process. When such growth takes place in bony tissue, its progress is so retarded by the obdurate structure that years are required before it manifests itself. Dew<sup>3</sup> stated that in the majority of cases, infestation occurs in childhood. Frequently, as in this case, injury precipitates the immediate symptoms. Faust<sup>5</sup> suggested that external trauma may provide a weakened site for the parasite to grow or accelerate a latent infection.

This patient kept a goat and a dog although she did not have the latter at the time of her illness. The extent of the growth would indicate, however, that she had acquired the disease as a child in Poland rather than from recent contacts with these animals.

Certain cases of human echinococcus disease are known to have been acquired in the United States. Although dog infestation is high in areas where it is endemic, Riley<sup>11</sup> stated that only once, in 1892, has a dog in the United States been proved infected. However, domestic animals in certain regions have been shown to have up to 20 per cent. larval infections. Riley<sup>11</sup> found hydatid cysts in the lungs of six out of thirteen mature male moose in Minnesota. When these cysts were fed to dogs, large numbers of adult tapeworms developed. Two out of three wolves examined from the same region harbored the adult form of echino-

coccus. Apparently the danger is from wild life which accidentally spreads the infection to domestic animals. Wild berries contaminated by infected fecal material may be another means of transmitting the disease.

Although hydatid disease of the bone occurs but rarely in the United States its possibility should be considered when pathological conditions of the bone are encountered.

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## SLIPPING OF THE UPPER FEMORAL EPIPHYSIS \*

BY MAX S. RABINOWITZ, M.D., BROOKLYN, NEW YORK

It is not the purpose of this paper to cover the entire subject of the treatment of slipping of the upper femoral epiphysis, or, for that matter, to quote from the rather extensive literature now available; but through the presentation of a small group of cases, to call attention to some points in the pathology and progress of the condition, and to sound again a note of conservatism in the treatment of the early cases. The divergence of opinion in regard to the treatment would in itself seem to indicate that a satisfactory method, universally applicable, had not yet been found. Wilson<sup>8</sup>, in an excellent article, calls attention to a number of methods of treating the very early cases, with minimal slipping, which, if the slipping were arrested, would give very satisfactory results. He cites valid objections to each of these methods. The use of the Smith-Petersen nail, suggested by him, is open to the criticism that, simple as the procedure is, it involves two open operations, as well as foreign-body fixation. It would seem that, if equally good functional and clinical results could be obtained by a less hazardous method involving only a good plaster technique, such a method would be generally more acceptable.

This series includes only early cases. There are eight cases, taken from the Services of Dr. Rushmore at the Long Island College Hospital, Dr. Kleinberg at the Israel Zion Hospital, and from the author's private practice. Of the eight cases, six were in the so-called preslipping stage and two had acute injuries with complete disruption of the epiphysis during the course of a gradual slipping.

Of the entire group, six were males, and two females. All but one exhibited a tendency to excessive weight, and the male cases seemed to fall into the endocrine dysplasia group with retarded gonadal development. All were treated by manipulation under anaesthesia followed by a plaster spica, applied according to the technique described by Kleinberg<sup>5</sup>, and employed as an ambulatory device. Ambulation was possible to an excellent degree in every case.

In the first six cases with minimal changes in the relationship of the head and neck, the histories were quite uniform. Symptoms were present for three to eight weeks, and consisted of a limp and slight to severe pain, ordinarily relieved by rest. The pain usually radiated down the thigh to the knee, though in some instances, the knee alone was complained of. In one case, strangely enough, pain was worse after resting and relieved by activity. Physical examination of the hip was characterized by limitation of abduction, internal rotation, and flexion. X-rays showed a loss of the overhanging superior lip of the epiphyseal cap, and a broadened, irregular epiphyseal line (Figs. 1-A and 2-A).

\* Read before the Orthopaedic Section of the New York Academy of Medicine, on March 17, 1939.



These cases were treated by manipulation under anaesthesia. The hip was manipulated into forced flexion, and then brought into a position of extension, with marked abduction and internal rotation. In this position, a spica was applied. The patients remained in the hospital only long enough to be x-rayed, and taught to stand, usually two or three days, and never more than a week. Weight-bearing with crutches was then not only permitted, but encouraged. The extent and effectiveness of the weight-bearing was manifested in the softening of the sole of the spica. Following removal of the spica at the end of about twelve weeks, crutches were used for five or six weeks until the patient's confidence returned. Rarely was any passive physical therapy employed. The

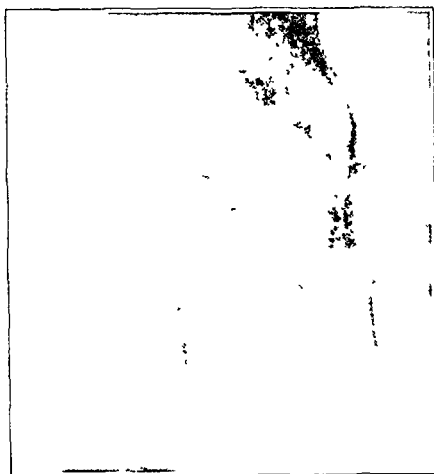


FIG. 1-A

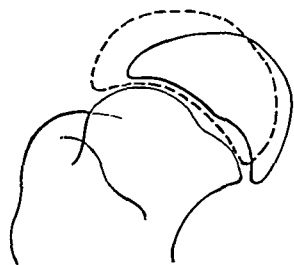


FIG. 1-B

Fig. 1-A: Case 2, aged twelve and a half years. Roentgenogram prior to treatment shows early slipping with marked broadening and irregularity of the epiphyseal plate.

Fig. 1-B: Indicates degree of slipping.

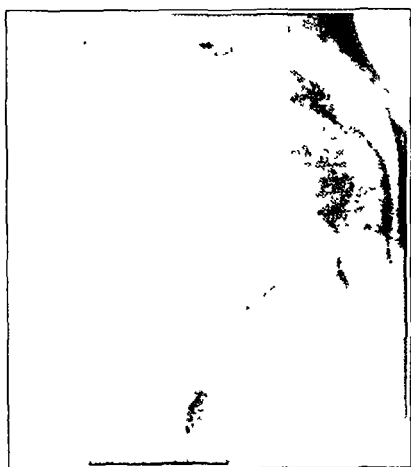


FIG. 1-C

Roentgenogram following removal of spica at three months shows epiphyseal plate narrowed and regular.

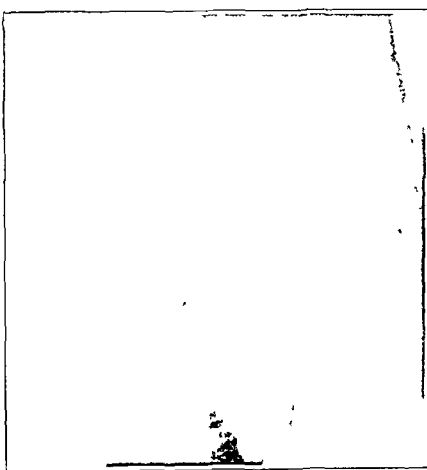


FIG. 1-D

Roentgenogram three years later shows epiphysis fused in excellent position. (Epiphysis on opposite side is still open.)

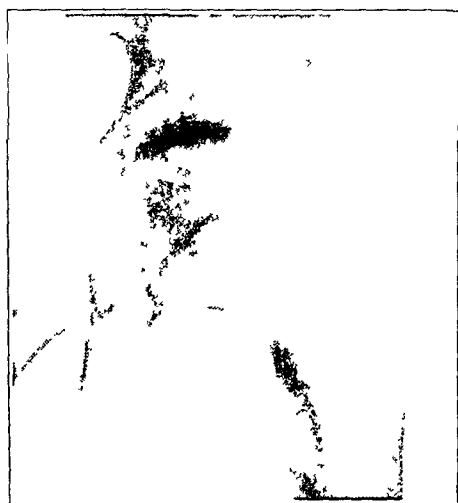


FIG. 2-A

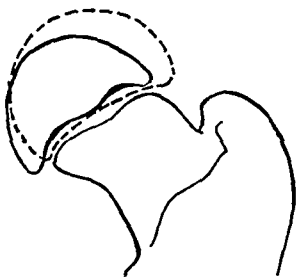


FIG. 2-B

Fig. 2-A: Case 3, aged fourteen and a half years. Roentgenogram prior to treatment shows early slipping with broadening and irregularity of epiphyseal plate.

Fig. 2-B: Indicates degree of slipping.



FIG. 2-C



FIG. 2-D

Roentgenograms two years later show epiphysis fused in excellent position. (Opposite epiphysis is open.)

Fig. 2-C: Anteroposterior view. Fig. 2-D: Lateral view.

functional and clinical results were excellent, and the roentgenographic studies after an average period of more than two years showed the capital epiphyses fused in very satisfactory position (Figs. 1-D, 2-C, 2-D, 3-C, and 3-D). It is not claimed that manipulation in this group affects the relationship of the head and neck, but rather that under anaesthesia, muscle spasm subsides, and a more satisfactory position of the extremity for weight-bearing is retained until fusion of the epiphysis occurs.

Two patients gave a history of early slipping to which apparently little if any attention was paid. There then intervened a sudden trauma resulting in acute slipping of the epiphysis with marked displacement (Fig. 3-A). It would seem that nature has here graciously, though somewhat perversely from the patient's point of view, done what we would have liked to do, but

have been unable to do effectively. The head and neck have been separated completely, and an opportunity is afforded to restore the relationship very accurately. Judging by the results of epiphyseal fractures in general, early and complete fusion can be anticipated in these cases as a result of the additional traumatization. There is one catch, however,—the reduction must be effected within a few days after the acute slip, or manipulation will be futile. Deformity and open operation are the penalty for the delay. In these cases the dislocation was satisfactorily reduced early by manipulation, and fixed by the method described. The functional end results were excellent, and roentgenograms revealed the epiphysis fused in satisfactory position (Figs. 3-C and 3-D).

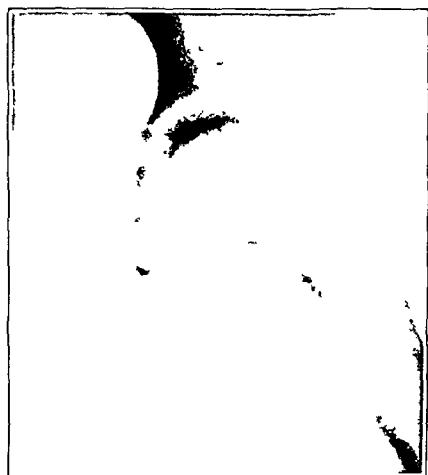


FIG. 3-A

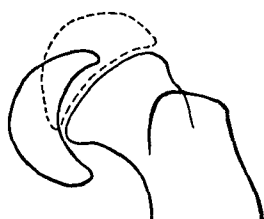


FIG. 3-B

Fig. 3-A: Case 7, aged twelve years, had gradual slipping with history of severe intervening trauma. Roentgenogram following acute injury shows complete disruption of head and neck.  
Fig. 3-B: Shows degree of slipping.

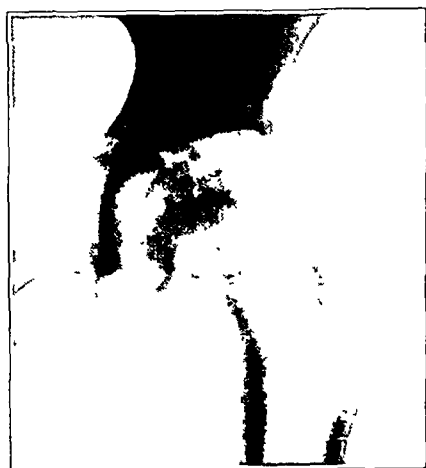


FIG. 3-C

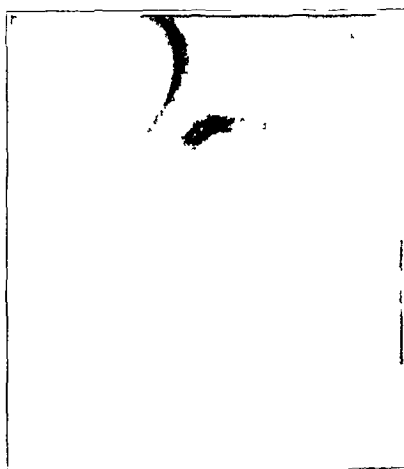


FIG. 3-D

Roentgenograms one and a half years after reduction show fused epiphysis in excellent position. (Opposite epiphysis is open.)

Fig. 3-C: Anterior view. Fig. 3-D: Lateral view.

TABLE I  
RÉSUMÉ OF EIGHT CASES OF SLIPPING FEMORAL EPIPHYSIS

	Sex	Age	Body Type	Side	Onset	Duration of Symptoms	Symptoms	Physical Findings
Case 1	M	14	Fröhlich	L	Spontaneous	3 weeks	Limp on the affected side. Slight to moderate pain in hip, occasionally referred to thigh and knee.	Limitation of abduction, internal rotation, and flexion, slight to moderate in degree.
Case 2	M	12½	Fröhlich	L		2 weeks		
Case 3	M	14½	Fröhlich	R		5 weeks		
Case 4	F	11	obese	R		4 weeks		
Case 5	M	11½	Fröhlich	R		4 weeks		
Case 6	M	14	obese	L		6 weeks		
Case 7*	M	12	obese	L	Fall on hip following previous history of pain and limp.	8 weeks before fall	Marked pain in hip with complete disability following the acute injury.	Like fracture. Hip maintained in external rotation. Marked local tenderness, and great pain on motion.
Case 8*	F	14	normal	R		5 months before fall		

\* Cases with severe intercurrent trauma.

#### COMMENT

It is the author's feeling that early weight-bearing in a group of patients already handicapped by obesity is a desirable consideration. Besides, the effect on the epiphysis seems to encourage early fusion in a manner less direct, to be sure, than that advised by Jahss<sup>4</sup>, Bozsan<sup>1</sup>, Telson, Mayer<sup>6</sup>, Ferguson and Howorth<sup>2</sup>, and Wilson<sup>3</sup>, but in my experience, none the less effective. All of these cases showed roentgenographic evidence of epiphyseal fusion within the period of treatment. In none of the cases did slipping increase during the course of the patient's activity in the spica, and it is the author's opinion that it will not occur if marked internal rotation and abduction are maintained. Another consideration, perhaps less significant but still worthy of thought, is the fact

TABLE I (Continued)  
RÉSUMÉ OF EIGHT CASES OF SLIPPING FEMORAL EPIPHYSIS

Roentgenographic Findings	Treatment	Duration of Treatment	Follow-Up Period (Years)	End Result	Final Roentgenograms	Rating
Signs of early slipping: broadening of epiphyseal line, and loss of overhanging superior lip of the epiphyseal cap (Figs. 1-A, 2-A).	Manipulation under anaesthesia into abduction, internal rotation, and slight flexion; application of a walking spica, and weight-bearing in 1 to 2 days.	Walking spica for 8 to 12 weeks, followed by the use of crutches for a variable period.	4½	No symptoms. Examination negative except for slight restriction of flexion.	No case showed progress of deformity. The capital epiphysis was completely fused in all but one case. The capitalepiphysis of the opposite hip was fused in none.	Excellent
			3	No symptoms. Examination negative (Fig. 1-D).		Excellent
			2	No symptoms. Examination negative (Figs. 2-C and 2-D).		Excellent
			1¼	Slight discomfort on fatigue. Slight limitation of abduction.		Good plus
			¾	No symptoms. Examination negative.		Excellent
			⅝	No symptoms. Examination negative except for slight limp.		Excellent
Complete epiphyseal slip, resulting from acute dissolution at the epiphyseal site (Fig. 3-A).	Reduction by Leadbetter manoeuver; application of walking spica cast; and weight-bearing in 1 to 2 days.	Spica for 12 weeks. Crutches.	1½	No symptoms. Examination negative (Figs. 3-C and 3-D).		Excellent
		Spica for 16 weeks. Crutches.	1½	No symptoms. Examination negative.		Excellent

that confinement and inactivity are particularly resented by adolescents. The security of the plaster gave this group a wide latitude in their activity, and their agility in the spica was in some cases little short of amazing. They remained cheerful and happy throughout the course of the treatment, and were, as a result, a much lighter burden on their parents. From the point of view of economy, the shorter period of hospitalization and the small amount of after-care also recommend this treatment.

#### SUMMARY AND CONCLUSIONS

We have presented a group of consecutive unselected cases, presenting the characteristics of slipping of the upper femoral epiphysis, in various stages, and in different types of individuals. It is evident that

in early cases the treatment described effects early fusion of the epiphysis with excellent preservation of function. Cases of gradual slipping in which an acute injury supervenes give especially satisfactory results if promptly treated. Unless special indications arise, conservative treatment by manipulation into forced abduction and internal rotation, followed by the use of an ambulatory spica, is a satisfactory method of treatment, and should not be entirely discarded for more radical methods.

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# INTRUSION OF THE SMITH-PETERSEN NAIL INTO THE ACETABULUM

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The possibility of intrusion of the Smith-Petersen nail into the acetabulum was first called to the author's attention by Dr. W. W. Plummer of Buffalo, New York, over a year ago. At that time he recounted his experience with a case, and discussed its probable mechanism. Since then the author has had a similar experience and this, together with the case which Dr. Plummer has kindly given us for publication, forms the basis of this report.

Before the nail became established as the method of choice for the treatment of fresh fractures of the femoral neck, critics pointed out that it frequently became loose and tended to extrude. In answer to this Smith-Petersen brought out the fact that in cases of absorption of the femoral neck it is necessary for the nail to be extruded unless the fragments are to be separated. According to most authorities, in the healing of fractures there is usually absorption of the contiguous ends of the fragments. This may be minimal in amount and not of clinical importance. However, careful comparison of roentgenograms in our fresh fractures of the femoral neck which have gone on to union, shows a measurable shortening, by the time union has occurred, in over two-thirds of the cases. The average change in these cases with shortening is about three-eighths of an inch (.95 cm.) although shortening of as much as three-fourths of an inch (1.9 cm.) occurred in some. It is a well known fact that even complete absorption of the femoral neck may occur in cases of non-union.

In these cases of absorption of the femoral neck, as well as in several other cases, the nail has usually been extruded. However, in the two cases being reported, the nail was so firmly fixed in the cortex of the femoral shaft that, as the neck shortened, the nail penetrated the acetabulum. In the first of these it is difficult to explain the reason for the fixation of the nail. In the second, fixation appears to be due to the overgrowth of callus over the head of the nail.

CASE 1. C. M., spinster, aged seventy-four, fell over a curb on October 20, 1938, and injured her right hip. She was treated at home in traction for three weeks before roentgenograms were taken. These showed a fracture of the femoral neck, and she was referred to us slightly over one month after her fracture.

The family history was not important, except that her father had died of paresis. She appeared a senile white woman. There was a loud systolic heart murmur with a collapsing pulse. The right lower extremity was in complete external rotation with an inch of shortening. Roentgenograms showed a transcervical fracture, somewhat oblique, with a protruding spicule of bone on the inferior margin of the proximal fragment. There was sclerosis about the margins of the fracture. An orthodiagram showed widening and





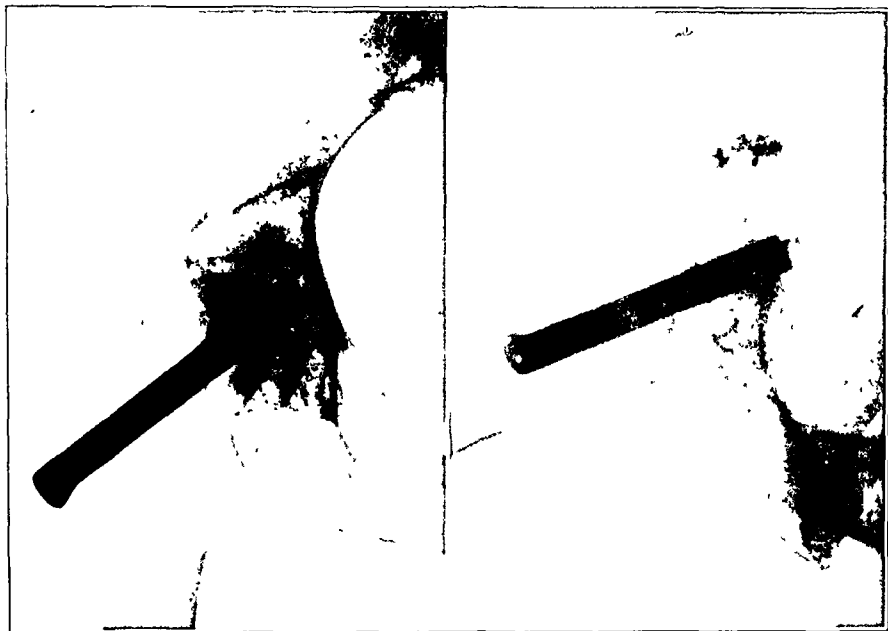


FIG. 2

Case 1. Roentgenograms show the joint just before the nail was removed. The nail had previously been extracted slightly from its original position. Note marked shortening of the femoral neck with the intrusion of the nail into the acetabulum.

after this length of time, was firmly fixed in the cortex of the femoral shaft, and was removed only after a strong pull with the nail extractor. After the nail was removed the fragments did not lose position, motion was more free and only mildly painful. She was discharged not able to bear weight. She was last seen February 19, 1940. Roentgenograms showed non-union with a dead femoral head. She refused further surgery and was given a walking caliper.

CASE 2.\* MRS. H. G., aged seventy, received an intracapsular fracture of the neck of the left femur in December, 1937. Immediate reduction was carried out, and closed nailing with a three-flanged Smith-Petersen nail was done. Roentgenograms taken after the nailing showed that satisfactory reduction and fixation had been obtained (Fig. 3).

Her convalescence was uneventful, and, at the end of four months, she was allowed up with crutches, but without weight-bearing on the affected extremity. A flat roentgenogram of the hip taken in April, 1938, showed the relationship of the fragments unchanged from the original x-rays. Another roentgenogram, taken July 18, 1938, still showed satisfactory position. However, on comparing this with the original x-rays taken at the time of nailing, there was evidence that the point of the nail was slightly closer to the capital cartilage than it was after the operation. At that time she had no discomfort in the hip, and the range of motion was satisfactory. She was permitted crutches, but not weight-bearing and was not very active.

About the middle of August, 1938, she began to have pain in the hip on motion. At first she did not give great attention to the pain as she had had hypertrophic spondylitis with involvement of various other joints, and was accustomed to some discomfort. The pain became worse, and about four weeks after its onset she was seen again for examination. At that time she showed definite evidence of intra-articular pathology. Motion of the hip was limited and painful. Roentgenograms made at that time showed

\* Dr. Plummer's case.

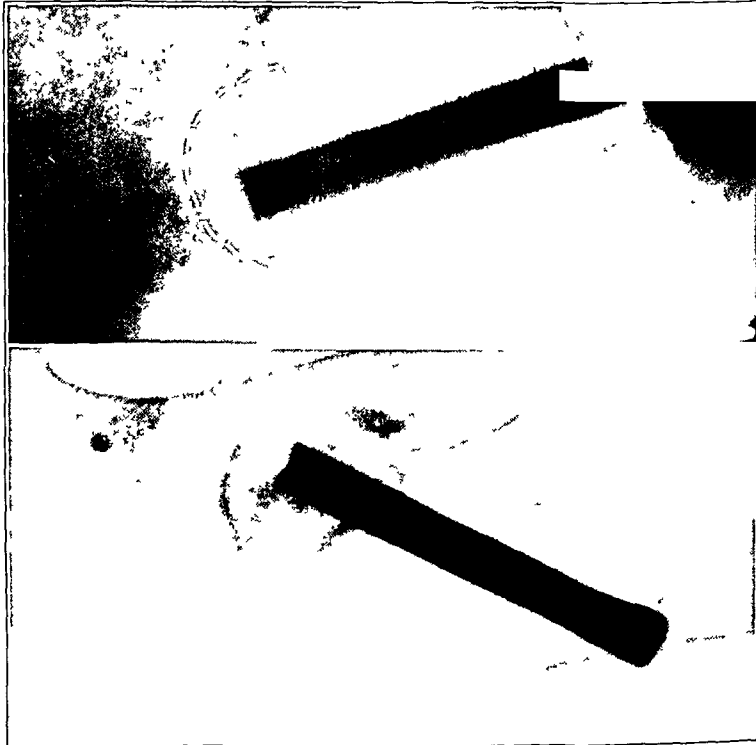


FIG. 3

Case 2. Postoperative roentgenograms showing satisfactory reduction, and position of the nail. The nail head appears slightly embedded in the femoral cortex.

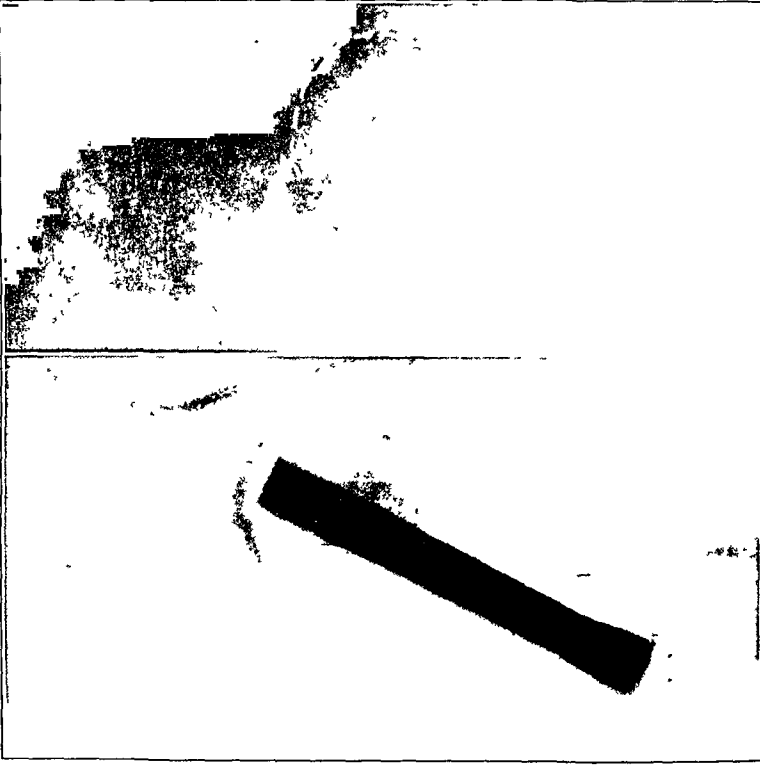


FIG. 4

Case 2. Roentgenograms show position of the nail before removal. Note callus over the head of the nail; varus and posterior displacement of the proximal fragment; and invasion of the acetabulum by the point of the nail.

definite protrusion of the nail through the head of the femur and into the acetabulum. The head of the femur was shown to be rotated posteriorly. There was an overgrowth of callus over the head of the nail (Fig. 4).

In October, 1938, the nail was withdrawn. Following this there was some improvement so far as the hip pain was concerned, but she was unable to bear her weight upon the leg. It was believed that the fragments had again become displaced, and that the head was undergoing aseptic absorption. No roentgenograms could be obtained to verify this conclusion. She died suddenly of a cerebral hemorrhage in February, 1940.

#### DISCUSSION

These cases are presented because it is believed that they represent a complication in the use of the three-flanged nail worthy of the attention of the surgeon. Felsenreich has already published a very detailed description of the histological pathology to be found in the hip joint following perforation of the femoral head by the nail. He has recognized shortening of the femoral neck as a cause of perforation, and faulty nailing as another; and has pointed out that if the nail only perforates minutely there may be a localized arthritis of no general significance. However, if it perforates grossly, as in these two cases, he has shown that there is a mechanical scouring of the hip socket by the nail point, which destroys the cartilage, and gives rise to loose pieces of cartilage in the joint. Felsenreich also stressed the fact that there may be solution of the nail by the synovial fluid, called a rust reaction, "*Rostgranulom*," which would cause chemical destruction of the joint cartilage. He found that this may extend through the cartilage over the head of the femur, and include destruction of the cortex of the head itself. He advised removal of the nail if healing had occurred or replacement by a shorter nail if it had not healed.

#### CONCLUSIONS

Two cases have been presented in which the nail was so firmly fixed in the cortex of the femoral shaft that, as the neck shortened, the nail penetrated the acetabulum. In the usual case, with similar femoral-neck shortening, the nail has been extruded. In the first of these two cases it is difficult to explain why the nail was so firmly fixed. In the second case fixation was probably due to an overgrowth of callus over the nail head. These two cases, and the observation that there is measurable shortening of the femoral neck in a large number of patients, point to the danger of mechanical fixation of the nail head to the femoral shaft. Such fixation has been advocated by several surgeons using various methods. Even when mechanical fixation has not been done, as in these two cases, the possibility of perforation of the femoral head should be considered whenever a previously satisfactory nailing becomes painful on motion.

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# THE TREATMENT OF THE CEREBRAL PALSIES \*

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There is such diversity of approach to the subject of the cerebral palsies that it is necessary to limit the present discussion to those data that have a relationship to treatment. In the past, little or nothing was done for this group of conditions. Spastic paralysis has been mentioned in the literature for more than 100 years, but athetosis and the ataxias of childhood have been mentioned only relatively recently. In 1826 Denis, Billard, and Cruveilhier suggested a causal relationship between intracranial hemorrhage at birth and spastic paralysis. Little presented his well-known monograph in 1862. He believed that 75 per cent. of all cases of spastic paralysis were due to cerebral hemorrhage at birth.

In 1910, Beneke described a new method of autopsy which would demonstrate tears of the tentorium and, hence, basal damage to the brain. It was this, more than anything else, which developed interest in the types of cerebral palsy other than true spastic paralysis. The possibility that these other types could also be due to injury at birth brought about great criticism of obstetricians which reached its height about 1920.

Since that time, the studies of etiology have shown that many factors, which are entirely beyond the control of the obstetricians, enter into birth injury, and that really poor obstetrics will account for only a very small number of the cases. However, cerebral palsy seems mainly a human condition, since its occurrence in any of the animals, even the anthropoids, is exceedingly rare. For a discussion of the various etiological factors, reference is made to the papers of Heyman, Schreiber, Pusitz, Langenskiöld, and others.

With regard to the treatment of the cerebral palsies, there has been until very recently, little or nothing in the literature. Certain procedures, such as nerve anastomosis, were described by Spiller and Frazier as early as 1905, and again by Allison and Schwab in 1910. Förster described posterior root resection in 1908, and Stoffel described neurectomy in 1911. The use of non-surgical, essentially physiotherapeutic, measures dates from the last decade of the nineteenth century, but no definite principles have been laid down.

More recently special procedures such as Chandler's operation on the tibial tubercle, Durham's operation for correction of internal rotation, Brewster's work with foot stabilization, Tubby's transplantation of the pronator teres, the various operative procedures for shoulder and elbow conditions, and many others have been developed. The results of

\* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons at Boston, Massachusetts, January 24, 1940.

TABLE I  
MENTAL STATUS OF 301 UNSELECTED PATIENTS WITH CEREBRAL PALSY

Classification	No	Per Cent.
Superior	15	5 0
High average	29	9 7
Average	88	29 2
Low average	35	11 6
Dull normal	40	13 3
Borderline	16	5 3
Feeble-minded	78	25 9
Total	301	100 0

these operations have varied widely. None of them seems entirely satisfactory, and yet all of them have enough value to be retained in the surgical armamentarium.

In undertaking a thorough study of the problem, it seemed advisable to assemble all the data that could be obtained with regard to the condition. Surveys in various parts of the country were begun three or four years ago, and as yet are far from complete. However, the number of cases surveyed is now large enough to show that the percentages obtained are not materially changing.

A survey of children two to sixteen years of age in the state of Maryland showed a yearly occurrence of seven cerebral palsy births per 100,000 population. This figure checks almost exactly in both rural and urban areas. In other parts of the country which have been surveyed, this ratio is also fairly constant. It is interesting that in Maryland, with a comparatively high Negro population, the percentage of cases found in the Negro race is much lower than in the white race.

TABLE II  
DISTRIBUTION IN SCHOOL OF 199 PATIENTS WITH CEREBRAL PALSY

School Status	No	Per Cent
2 grades advanced	1	0 5
1 " "	4	2 0
At grade for age	32	16 1
1 grade retarded	41	20 6
2 " "	29	14 6
3 " "	30	15 1
4 " "	13	6 5
5 " "	11	5 5
6 " "	16	8 0
Special class	22	11 1
Total	199	100 0

TABLE III  
DEGREE OF HANDICAP OF 271 PATIENTS WITH CEREBRAL PALSY

Degree of Handicap	No.	Per Cent.
Mild	75	27 7
Moderate	120	44 3
Severe	76	28 0
Total	271	100 0

This figure then, in a city of 100,000 would represent seventy patients under ten years of age, or 140 under twenty years of age. It would be lowered by those dying during childhood, but increased by those over twenty-one, since most of these surveys did not include any cases over twenty-one. By means of this figure, the general assumption can be made that there must be in the United States at least 150,000 cases of cerebral palsy.

A study was made in New Jersey to determine what percentage of cases had sufficiently high mental status to become worth-while members of society, if the physical difficulties could be alleviated. A chronological series was studied for mental status by McIntire with the findings shown in Table I. It may be seen that those grouped in the first five classifications constitute 68.8 per cent. of the total.

These results were checked, where possible, with school records. It is interesting that of those checked, those who were not more than three grades retarded again constituted practically the same per cent., 68.9. These figures are entirely independent of the degree of handicap, but are for the same groups which were studied orthopaedically.

The degree of handicap in 271 cases was judged arbitrarily and is shown in Table III. The degree of handicap is not an indication regarding treatment.

Table IV gives the extent of the handicap, or part of the body involved.

The totals in the tables, which are based on the New Jersey survey,

TABLE IV  
EXTENT OF HANDICAP OF 306 PATIENTS WITH CEREBRAL PALSY

Extent of Handicap	No.	Per Cent.
Quadriplegia	175	57 2
Triplegia	23	7 5
Hemiplegia	67	21 9
Paraplegia	36	11 8
Monoplegia	5	1 6
Total	306	100 0

vary because all data were not obtained on each case. However, all cases are included in which the data were recorded.

Bearing in mind that 68.8 per cent. of cases show good mental ability, and that 72 per cent. are of mild or moderate degree of severity, it would seem that the problem of the cerebral palsies includes a large number of patients who would justify the time and expense of treatment. It should be remembered, however, that severity of involvement is not always a contra-indication to treatment. It may be highly desirable, for example, to rehabilitate the hands for self-care and ability to use a wheel chair in a quadriplegic whose legs are hopeless.

There is no one class or economic status in which the condition is more prevalent than in any other, and the distribution is fairly even. Hence, the number of patients able to pay for their own treatment is in direct proportion to the economic status of the population at large.

The condition differs particularly from poliomyelitis in that there are no epidemics, and no unforeseen developments. There is at present little hope of checking the condition, and the problem of care and treatment can, therefore, be prepared for in advance.

Treatment depends first, upon a careful diagnosis of the particular kind of cerebral palsy. For several reasons, the cerebral palsies have been divided into three general types — spastic, athetoid, and ataxic.

Spasticity is characterized by the stretch reflex. Hence, the way an attempt to move will be blocked is always predictable to the patient. Spasticity is a pyramidal-tract condition, often cortical, and, hence, the type in which true mental deficiency is most likely to occur. Spasticity is susceptible to muscle examination because of the fixed nature of the condition, and, therefore, susceptible to surgery.

Athetosis is characterized by involuntary motion, so that interference with an attempt to move is never predictable to the patient. Athetosis is a basilar or non-pyramidal-tract condition, and the type in which true mental defect is not likely to occur. Athetosis is not well-suited to muscle examination, since the motions are total joint "attempts" and will persist with what muscles are left even if some are cut, neurectomized, or transplanted. Consequently, athetosis is not improved by peripheral surgery (at least as we know it now), except for the correction of true contractions.

Spasticity resembles athetosis because the stretch reflex may start a whole train of involuntary motions, and because some of the reflexes may not appear to be hyperactive if the muscles being tested are not spastic muscles.

Athetosis resembles spasticity because of the voluntary, often habitual, tension set up to stop the involuntary motion, and because some of the reflexes may appear to be hyperactive, due to the automatic reinforcement by involuntary motion elsewhere in the body, or by tension.

Ataxia is a disturbance of balance and postural or directional sense, without interference with motion either by spasticity or involuntary mo-

TABLE V

DISTRIBUTION OF TYPES OF PARALYSIS IN 350 PATIENTS WITH CEREBRAL PALSY

Type of Paralysis	No.	Per Cent.
Spastic	189	54 0
Athetoid	143	40 9
Ataxic	18	5 1
Total	350	100 0

tion. It is, also, not susceptible to surgery, except for correction of true contractures.

Table V shows the distribution of these types of cases in a consecutive series in New Jersey.

The author's series of eighty-nine cases was observed for a period of two years at the Children's Rehabilitation Institute, a boarding-hospital-school for cerebral palsy patients. They ranged in age from three to thirty-two years, though almost all were under twenty-one. The proportions of spastic, athetoid, and ataxic cases were similar to those in the surveys, but the average mental status was considerably higher because the Children's Rehabilitation Institute does not accept definitely defective children.

#### GENERAL PRINCIPLES OF TREATMENT

##### *Spasticity*

A complete muscle examination should be made in all cases. For this purpose the usual muscle-examination forms used in poliomyelitis are entirely satisfactory. However, the muscles should be graded essentially according to those which show spasticity; those which are normal; those which are weak (but otherwise normal); and finally those which the patient is unable to contract. Spastic muscles are tested by means of eliciting the stretch reflex. An attempt is made to move the joint rapidly in the opposite direction to that of the contraction of the muscle under observation. As soon as the motion begins to take place, the stretching causes a contraction of the muscles, blocking free motion. Normal or weak muscles are tested in the usual way, but allowance must be made for the possible spasticity of their antagonists before making a final decision. Flaccid muscles are those which the patient is unable to move voluntarily even if their antagonists are normal. These can be made to contract in some instances by means of resisted contractions in other parts of the body. These confusion contractions are very useful in retraining cerebral-flaccid muscles.

No surgery should be performed on a spastic patient without a muscle examination, as the condition of the antagonists of the muscles under consideration is often the deciding factor in determining the procedure.

In conservative treatment, the flaccid muscles and weak muscles must be protected from the weakening effect of undue stretching, and the spastic muscles must be protected from the strengthening effect of the



stretch reflex. With treatment by selective massage, and careful exercise with appropriate splinting and protection, a great change in muscle balance may be attained. The amount of surgery apparently necessary at first will be greatly diminished.

### *Athetosis*

In this condition a muscle examination will demonstrate those muscles which move involuntarily and those which do not. This picture remains relatively fixed, but it is the *motions* carried out by the athetosis rather than the muscles which really give the fixed picture. Patients have been seen in which previously athetoid muscles have been thrown out of function, either by neurectomy, tenotomy, or even transplantation, and the direction of the athetoid *motion* remains unchanged as long as there is any muscle power left to move it in that direction. Thus, athetosis seems better conceived as an involuntary attempt to move a joint in a certain way, than as an involuntary stimulation of any individual muscle. Surgery of the muscles, nerves, or tendons, has, therefore, very little effect. Joint stabilizations are exceedingly difficult in athetosis because it is almost impossible to maintain enough fixation for good fusion. The discomfort of the patient following the operation is very great, and there is much difficulty with pressure sores. In general, surgery is unsuccessful. In severe cases Putnam's procedure of lateral cord section is helpful, but it serves more to quiet the athetosis than to increase function. The use of curare, as described by Burman, is still definitely experimental, but its further development should be watched with interest.

Relaxation, taught by a carefully graded system, beginning with the least athetoid parts of the body and, when learned, extended to the more athetoid extremities, is, over a long period of time, very effective. This, combined with motion from the relaxed position, is the most effective form of treatment, and eventually brings about very satisfactory results.

### *Ataxia*

The treatment of this condition is simply that of training the voluntary motor centers to take over the function of the damaged balance mechanism. It can be compared to the learning of any other skill, such as playing the piano. At first, all the attention must be fixed on the skill being learned, but later it can be carried out almost without thought. Thus, with sufficient practice, the skill of balance and directional control can be learned in a similar manner, and eventually becomes habitual.

Because of the fact that, in general, the various disturbances of the motor system constituting cerebral palsy start at birth, many essential fundamental motor patterns, such as reciprocation in the legs, and the reach and grasp in the arms, usually learned during early babyhood, are not automatically developed. Without these two, especially, neither

walking nor the proper use of the arms is possible. Besides this, many bad habits in use of the arms and legs are established, frequently very early. These become fixed, as does the assistance given the child by the family (their habits toward him), so that retraining is badly handicapped. The educational difficulties are also great, and frequently require special methods.

The ideal method of training these patients is, therefore, in a school or institution especially set up to meet their needs both physically and educationally, until such time as the bad habits can be broken up, and rehabilitation carried out to the point where the children can be entered in a day school.

There is great danger of old habits returning at home, because they are so closely bound up with the home environment. However, a period of institutional life long enough for the children to establish new habits of use of muscles and of care for themselves, associated with an intensive educational stimulus, is very effective in preparation for future placement in a day school.

It seems essential, however, that, after discharge from the institution, treatment be continued individually, at least three times a week, for a considerable length of time to insure fixation of progress. Treatment should be tapered off very gradually, over a period of years in most cases, as the skills which are taught take the place of the exercises.

Home treatment in some instances is, nevertheless, very effective. While it is not possible to train a mother or nurse to treat all cases, it is entirely possible, in a week or so, to train most intelligent mothers or nurses to treat one individual child. After demonstrating the work thoroughly to the mother, and watching her carry it out under direction, a very carefully worked out schema, with detailed directions for that particular child, should be given to her. This home treatment cannot be generalized, but must be especially worked out for each individual child. The mother or nurse then carries out the procedures daily with return of the patient to the physician at frequent intervals.

The obtainable results are in three fields,—use of the legs, use of the arms, and speech. The disorders of speech in cerebral palsy are an extensive source of investigation at present, but, in brief, they are exactly parallel with the difficulties in the arms and legs. They are spastic, athetoid, or ataxic, and the same principles of treatment apply. Satisfactory progress can be made only if the speech trainer thoroughly understands the type of underlying difficulty. In this field also habits of use are the greatest obstacles to overcome.

Results in the legs are measurable in the perfection of gait. In some instances it is possible to teach walking even as late as adolescence, if the right fundamentals are stressed. Two such cases were sixteen-year-old athetoid girls who had never walked previously. Their difficulty was that they had not learned the underlying principle of reciprocation. Another was a twelve-year-old ataxic. Others are taught to

walk with heel placement instead of toe placement, and other improvements—such as speed of walking and better appearance of gait—can be made.

In the use of the arms the results are harder to evaluate, but ability to dress and feed oneself is a good measure.

In speech the results are slower, but a few can be taught to speak, and the defective speech in others can be cleared up.

In the school proper, the teaching is aimed at bringing the children up to their grade level in all subjects, and this can be accomplished in the majority of cases with the use of special teaching methods.

A careful study of each child should be made with regard to rehabilitation for adult life. This is usually carried along two chief lines which point toward vocational and avocational interests, and the physical and mental abilities are trained toward these ends.

#### SUMMARY

1. Cerebral palsy, representing about seven births per 100,000 population per year, presents a real problem with regard to the number of cases.

2. Mental level is sufficiently high in about 70 per cent. of the total to make treatment worth while.

3. The incidence of the condition, unlike epidemic poliomyelitis, is at present entirely predictable, and plans can be made in advance for treatment of a definite number of cases.

4. The importance, with regard to treatment, of accurate diagnosis of spastic, athetoid, and ataxic palsy, must be emphasized, even though differential diagnosis is occasionally very difficult.

5. The present use of surgery is essentially limited to the true spastic, except for contractures.

6. The most effective method of treatment is the special school where physical reeducation and schooling can be carried out together.

7. There must be close cooperation and mutual understanding of the problem among the educators, the doctors, and the family of the patient.

8. Home retraining is, in some instances, very effective, and, in most cases, should at least be given a trial of several months before deciding on the special school.

9. Satisfactory results, judged by the standards of other crippling conditions, are obtained when care and treatment are sufficiently intensive.

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# LEGG-PERTHES DISEASE OF THE HIP: ITS EARLY ROENTGENOGRAPHIC MANIFESTATIONS AND ITS CYCLICAL COURSE \*

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The name Legg-Perthes disease of the hip is employed for want of a better one. Legg-Waldenström-Calvé-Perthes disease is too cumbersome a title. Coxa plana is incorrect because the head does not become flattened if, during the course of this disease, it is protected from weight-bearing and muscle spasm. There is no evidence in support of osteochondritis as the disease is not one of inflammation of bone and cartilage. The primary fault is not in the acetabulum; so this disease cannot be called pelvis plana. One must sharply differentiate the true Legg-Perthes disease from a somewhat similar condition which is often observed in the head of the femur in cases of congenital dislocation of the hip.

## ETIOLOGY

The etiology of this disease has not been determined. The author has observed the onset of symptoms in children between the ages of three and eleven years. There is reason to believe that the hips have been normal before the onset of the disease because, at the very beginning of the changes that are visible in the roentgenogram, the affected hip is entirely similar to the opposite unaffected one in size, shape, and density, except for the evidence of local necrosis that will be mentioned later.

Between 85 and 90 per cent. of the patients are boys. This is the reverse of the sex incidence in congenital dislocation of the hip.

A history of definite injury immediately preceding the onset of symptoms has been obtained in a few cases. More frequently such history is lacking.

Some cases show definite evidence of endocrine imbalance. This is suggestive of an etiological factor, but it cannot be accepted as the sole or universal one unless it can be proved in all cases of Legg-Perthes disease.

## SYMPTOMS

The first symptoms are pain, more commonly felt in the region of the knee than the hip, and a limp in the affected leg. These symptoms are not often continuous. They frequently disappear after rest in bed for a few days. On first examination there is always some limitation of normal motions of the hip, particularly that of rotation of the femur. This sign also disappears readily after rest. There may be slight wasting of the muscles of the thigh; and a slight firm thickening of the hip can almost always be felt by careful palpation. At the onset of symptoms the

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disease may be in an early stage or it may be far advanced. The author has seen cases within three weeks of the appearance of the first pain or limp, and the roentgenograms have shown marked necrosis of the head and the neck of the femur.

We have been able to study a number of cases, however, which presented the very early changes which are visible in this disease and, in several cases, even before the onset of symptoms. The striking and uniform feature is an early necrosis in the metaphysis of the neck of the femur. The areas of decalcification vary in number, size, shape, and location in the metaphysis. These irregular "holes" may first appear at the outer margin of the neck, or in the center, or, less commonly, at the inner margin. They may be small and irregularly rounded, or large and conical with the base of the cone upward against the epiphyseal plate. As time passes they multiply, enlarge, coalesce, and form a broad band across the entire metaphysis. Sometimes the band-like area of decalcification is seen in the first x-ray that is taken. It was discovered accidentally in the x-ray laboratory of the University of Pennsylvania that if the x-rays are slightly overexposed these areas of decalcification stand out more clearly.

#### DEGENERATION

The next feature found in our early cases is that concomitant or subsequent degenerative changes occur in the head of the femur, and that the first area of necrosis in the head directly overlies the first area of necrosis in the metaphysis. As the disease spreads in the metaphysis, it extends correspondingly in the head. It is difficult to escape the conclusion that the degeneration of the head is the result of the necrosis in the neck.

From these early beginnings the progress of the pathological process is well known: the appearance of irregular areas of decalcification in the head; the so-called fragmentation; isolated areas of increased density, which gradually become smaller until they may almost completely disappear; and the change in the size and shape of the head which becomes smaller and flatter until it may be barely visible. At times the head seems to have been almost entirely destroyed, as it appears only as a small, obscure body, not more than one-fourth inch in diameter, lying above the center of the metaphysis.

This phase of degeneration and disintegration extends through a period of about a year and a half. A study of more than twenty cases shows that there is some variation in the time consumed in this process. As mentioned above, the disease may be far advanced and of many months' duration before the onset of symptoms, and, therefore, before the first observations are made. In such cases it is difficult to compute the time occupied in the first part of the phase even though in each case the number of months that have been required to complete the degeneration have been determined. Furthermore, the lack of proper treatment,—that

is, continuous and prolonged rest—during this phase prolongs the time. From the writer's observation of the rate of degeneration in the cases followed continuously from the appearance of the early signs, it is possible to estimate approximately the duration of the disease in those cases which are first seen when the disease is well advanced. Combining all these factors it seems probable that the degenerative stage occupies, on the average, a period of about eighteen months; that it is prolonged beyond this period by lack of treatment; and shortened by adequate treatment that begins in the very early stage. Table I illustrates these statements.

#### REGENERATION

After the period of degeneration is completed that of regeneration begins. The turn in the cycle usually occurs abruptly. Our roentgenograms are taken at two-month intervals and the change from progressive destruction to a beginning reconstruction can be noted in two successive x-rays.

The regeneration is usually apparent in the metaphysis before it shows in the head. The decalcified areas in the neck begin to disappear as new bone forms. Then recalcification appears in the head. The areas of fragmentation begin to fade out; there is less density in the islands; and new bone appears in the portions of the head that were invisible. The head develops toward the margins and increases in thickness. The portions of the head and neck that showed the earliest evidence of necrosis are the first to show evidence of recovery. The metaphysis is restored to a normal appearance a long time before the regeneration of the head is completed.

The time required for complete regeneration is approximately between two and three years. This phase of the cycle is probably also delayed by absence of proper treatment. When it is finished the head and neck are restored almost to normal size and shape, and the acetabulum is normal if treatment by non-weight-bearing has been carried out consistently from the beginning. If there has been inadequate or no treatment, the well-known deformities of the head, neck, and socket are observed.

The fact that regeneration first appears in the metaphysis and is completed there first again points to the conclusion that the changes that occur in the head are dependent upon the primary changes in the metaphysis. If the necrotic neck is subjected to the crushing force of weight-bearing and of muscle spasm it becomes shortened and broadened. If it is protected from this force, it heals with but little or no deformity.

The eventual size and shape of the head are governed by the same principle. When the head regenerates, if it is well shaped, it sits on top of a well-shaped metaphysis; if it is deformed it rests upon a correspondingly deformed metaphysis. It regenerates through the regenerating epiphyseal plate and its underlying metaphysis.

We agree with Waldenström that the subluxation of the head and the accompanying thickening of the floor of the acetabulum are due to the flattening of the head when accompanied by weight-bearing and muscle pull. However, our cases show that if the softened head is protected from these forces it does not become flattened or subluxated, and the acetabulum does not become altered. We disagree with Waldenström in that we think the primary change is in the metaphysis and the epiphyseal plate, and not in the head.

Our present conception of Legg-Perthes disease is that it is due to a primary aseptic necrosis in the metaphysis. The necrosis is due to an interference with or blocking of the blood supply. The cases which show a large conical area of destruction point to thrombosis of a large vessel, and infarction. The cause of the circulatory damage is as yet unknown. The degenerative changes that occur in the head are also of the nature of aseptic necrosis, and are due to cutting off the blood supply through the metaphysis and the epiphyseal plate. The deformities that arise are due to the mechanical forces of weight-bearing and muscle tension. The fact that the necrosis in the neck is frequently slowly spreading and progressive would point to some constitutional cause rather than to a single traumatism.

#### DIAGNOSIS

The diagnosis is easily made when the pathological process is fairly well advanced, but it is attended with some difficulty in the very early stage. The appearance of necrosis in the metaphysis is so constant that the author is unwilling to make an x-ray diagnosis of Legg-Perthes disease without its presence. Careful comparison with the other femur, the use of magnifying and reducing lenses, and a moderate overexposure of the film will aid in its detection.

The author wishes to emphasize the value of careful palpation of the hips. If one sits on the side of the bed and places his fingers in the fossa behind the head and the neck and his thumb over the head in front, he thus grasps the hip between the thumb and the fingers. If he grasps the other hip in a similar manner with his other hand, he is able to feel a very slight difference in the thickness of the two hips, and to appreciate the nature of the thickening, whether it is soft or whether it is firm and resistant. A slight, but evident, firm thickening can almost always be felt in Legg-Perthes disease. Our records show that this diagnosis has often been made during the past ten years by palpation, and before x-ray examination has been made.

There is also an early thickening of the hip in tuberculosis. Indeed, the correct diagnosis can be made with the hands before it can be made by the x-ray appearance. But in tuberculosis the thickening is soft and more marked. This clearly distinguishes it from Legg-Perthes disease. Inasmuch as early x-ray diagnosis of these two conditions is frequently confused or undistinguished, the use of skillful palpation is of the greatest value.





FIG. 1-A

March 13, 1937. Very early necrosis of the inner and outer margins of the metaphysis. Very early decalcification of the outer margin of the head. Head is of normal size and shape; and acetabulum is normal.



FIG. 1-B

May 5, 1937. Necrosis of the inner and outer margins of the metaphysis is more evident, and is beginning to appear also in the entire metaphysis. Decalcification of the inner and particularly of the outer portion of head is more evident. Head is becoming thinner.

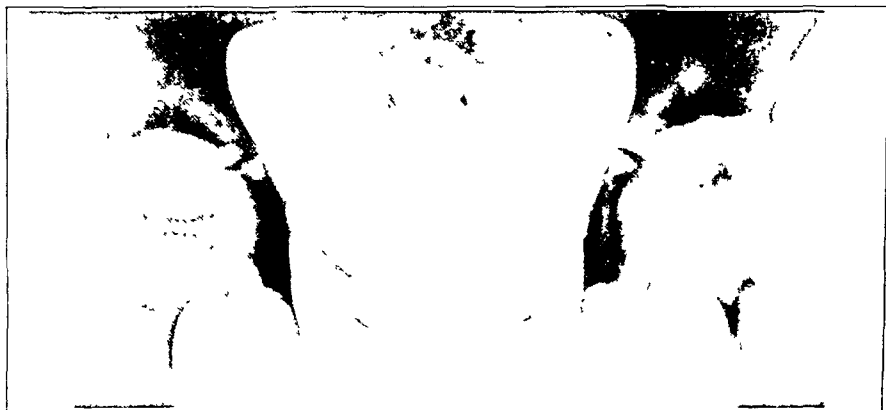


FIG. 1-C

September 22, 1937. Marked increase in the necrosis of the outer third of the metaphysis and extending downward almost to the greater trochanter. A well-defined narrow band extends across the entire metaphysis. Decalcification of outer third of head is marked, of the inner third moderate. There is increased density of the central portion of head, which is thinner.

## CASE 1 (Continued)



FIG. 1-D

November 22, 1937. Necrosis of neck is not progressing. Destruction of the head is more marked, particularly in the outer third above the most marked area of necrosis in the metaphysis. Inner third of the head also shows advancing necrosis.

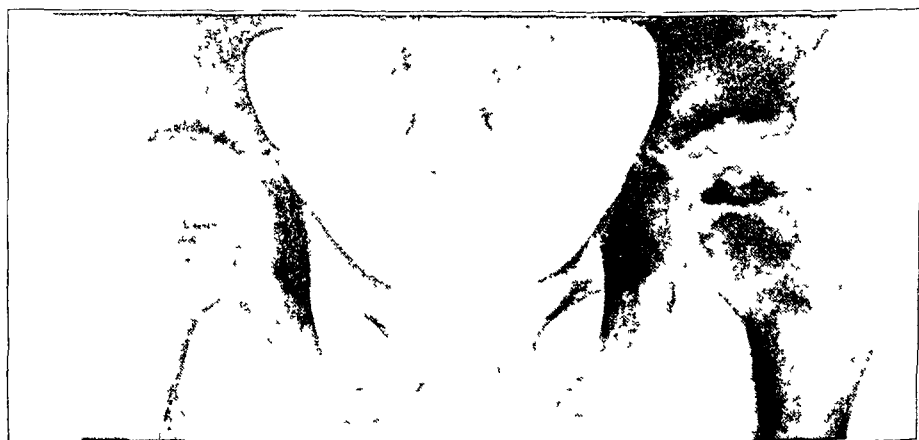


FIG. 1-E

March 7, 1938. The cycle has turned upward. Metaphysis is regenerating. Necrotic areas are barely visible. Recalcification of head is beginning and is most evident in the outer and inner thirds.

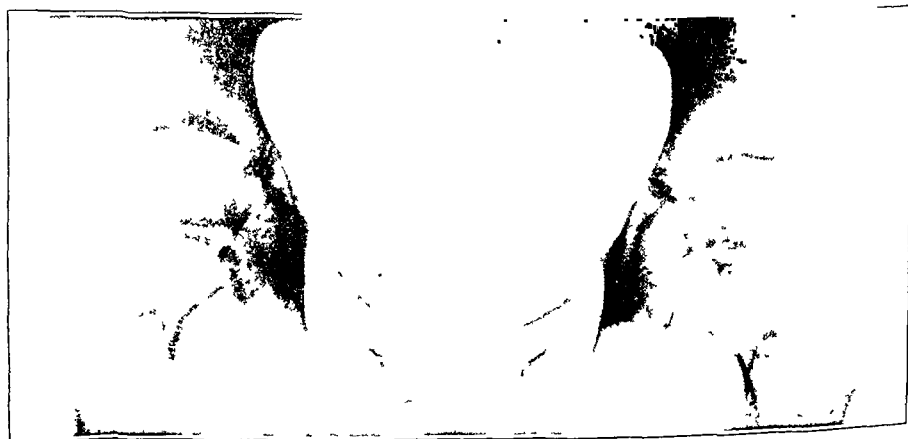


FIG. 1-F

September 13, 1938. Neck is practically healed. Head is of more uniform density. Hole in outer third is filling in. Central third, which was the last to show degeneration, is the last in regeneration.

## CASE 1 (Continued)

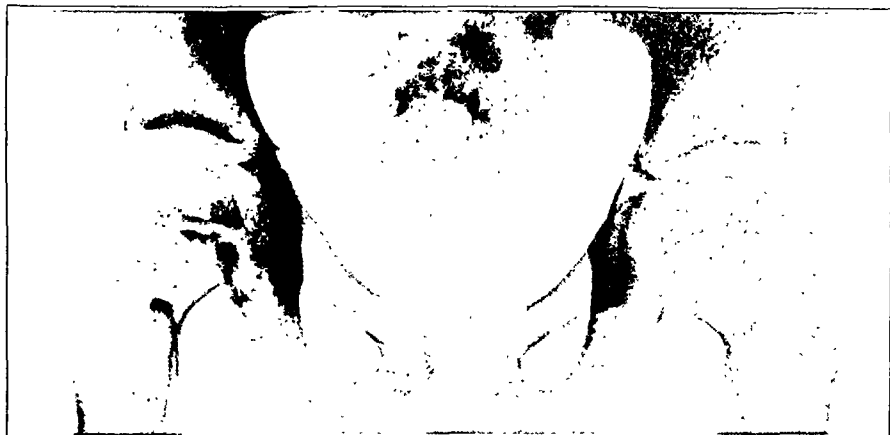


FIG. 1-G

February 7, 1939. Head is larger and rounder. Central third lags behind other thirds.

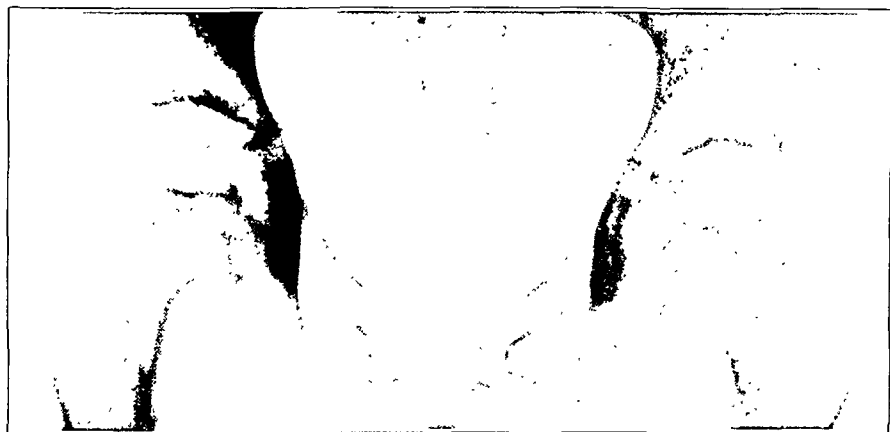


FIG. 1-H

June 9, 1939. Neck is healed. Head is fairly well regenerated except for superior central portion.



FIG. 1-I

October 23, 1939. Neck is slightly broadened, not shortened. Head, regenerated except for the superior central portion, is slightly thinned, well-rounded, slightly broadened.

Routine tuberculin reactions have always been negative in Legg-Perthes disease, and the blood sedimentation rates have always been within normal limits.

#### SLIPPING EPIPHYSIS, EPIPHYSIOLYSIS

It is interesting to note that in this condition there is also an early, marked, bandlike necrosis of the metaphysis. It is often observed in boys who present a Fröhlich's syndrome, but it does not lead to the degenerative changes of the head that characterize Legg-Perthes disease, and healing takes place in a much shorter time. We do not know why this should be so. It suggests that the pathological process in Legg-Perthes disease is more serious and profound.

#### TREATMENT

In our earlier experience with the treatment of this condition we followed Legg's dictum that the disease ran a definite course which was not modified particularly by any form of treatment. But after Danforth's paper in 1934, we began to follow his method of prolonged rest in bed. Whenever possible the child is put to bed with Buck's extension on both legs, and is kept in bed until regeneration is well advanced. We then allow the child to go about with a walking brace with perineal crutch, high shoe on the well leg, and crutches. When we are able to carry out this method without interruption, the end results are practically perfect hips.

We are still uncertain when we may safely allow weight-bearing, but believe that regeneration should be well advanced when it is permitted.

Medical and dietary treatment with a full complement of vitamins should be carefully supervised.

*Drilling:* It is impossible to determine the results of such treatment unless one knows fairly accurately the phase of the cycle when the drilling is done. If the operation is performed near the end of the period of degeneration it might falsely be credited with the improvement which would follow naturally as the cycle begins its normal upward swing.

*Endocrine Therapy:* The same observations hold true for endocrine therapy as for drilling. The point to be determined is whether these methods shorten the time of one or both phases of the cycle as determined by treatment by prolonged non-weight-bearing. We have reason to believe that the cycle is lengthened when weight-bearing is permitted.

*Shelf Operation:* The author has used this method of operation when the disease has been neglected and is far advanced, with subluxation and deformity of the head and insufficiency of the socket. It has successfully added stability to the hip, and has apparently prevented increase in the deformity of the head.

#### CASE REPORTS

Case 1: B. G., male, aged five years, was presented for examination March 13, 1937. The history included a fall in October, 1936, in which patient struck left hip against the curb on the street. He was apparently well the following day, but developed a limp in

CASE 2. W. C. (Figures 2-A through 2-I.)



FIG. 2-A

April 28, 1937. Necrosis is well advanced in the central and outer portions of the metaphysis and in the corresponding part of head. Head is smaller and flattened; acetabulum is normal.



FIG. 2-B

September 3, 1937. There is necrosis of the entire metaphysis; entire head is degenerating.



FIG. 2-C

November 5, 1937. Necrosis of the head is more advanced and is most marked in the central and outer part where it began.

## CASE 2 (Continued)



Fig. 2-D

February 22, 1938. Fragmentation of the head is more marked. Metaphysis shows beginning healing; decalcification is less marked.



FIG. 2-E

April 26, 1938. Healing of the central and outer part of head is beginning; density is more uniform. The cycle has definitely turned.

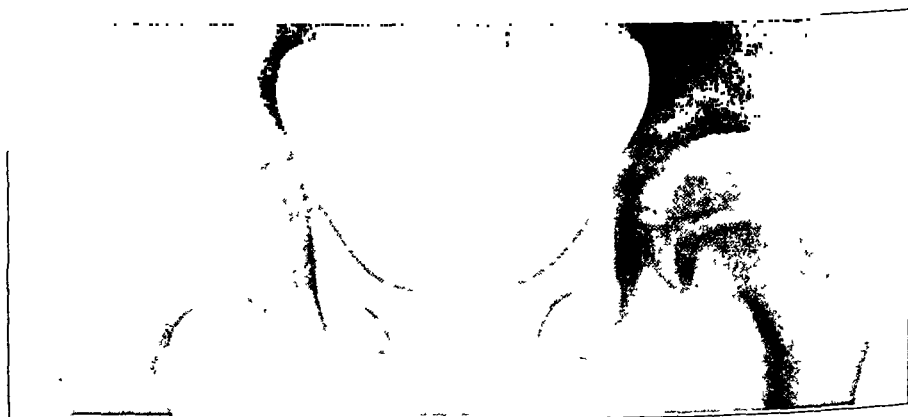


FIG. 2-F

September 8, 1938. Healing is well advanced. Head is flat, broad, and extends slightly beyond the acetabulum.

## CASE 2 (Continued)



FIG. 2-G

December 13, 1938    Regeneration is progressing.



FIG. 2-H

March 23, 1939.    Head is less mottled, more round, with the articular margin smooth.

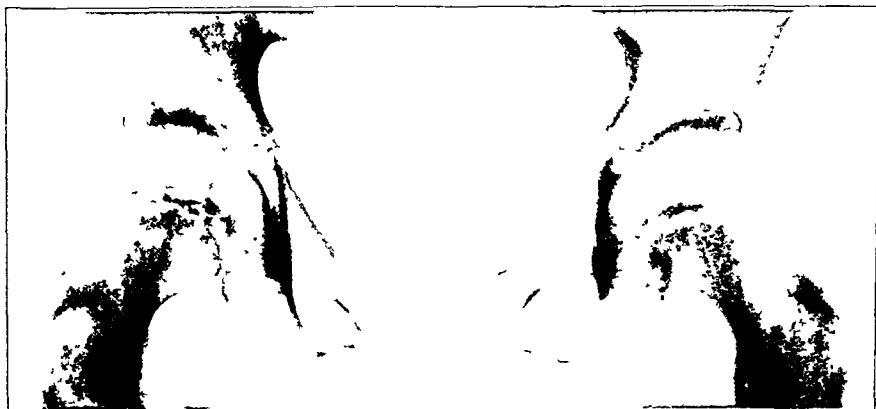


FIG. 2-I

August 10, 1939.    Regeneration is far advanced. Upper end of the neck is but one-sixteenth of an inch wider than the neck of the left femur. There is no shortening. Head is one-sixteenth of an inch thinner than the left, well rounded, and protrudes slightly beyond the acetabulum. Regeneration is not yet completed.



FIG. 3-A

December 15, 1936. Necrosis of the outer third of the metaphysis and the head is marked. Head is small, dense in center, and fragmented in the outer third.



FIG. 3-B

January 27, 1937. Necrosis of the inner third of the metaphysis is becoming more evident.



FIG. 3-C

June 7, 1937. Necrosis has extended entirely across the metaphysis. Entire head is fragmenting.

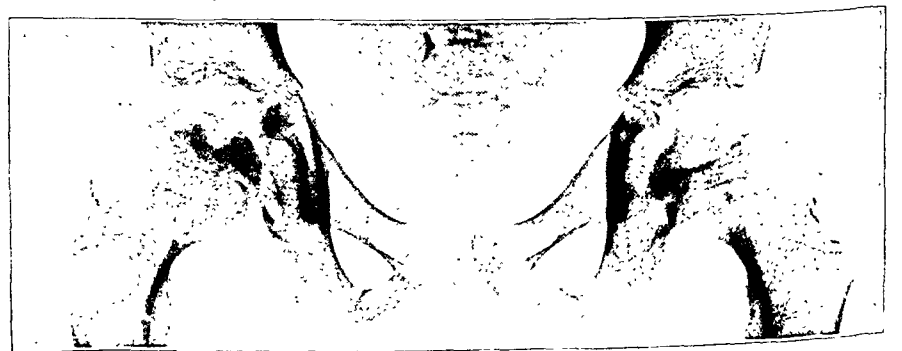


FIG. 3-D

September 3, 1937. Regeneration of the outer third of the metaphysis is apparent, but is not so marked in the inner third. Head is showing regeneration in the outer third.



## CASE 3 (Continued)



FIG. 3-E

August 25, 1938. Metaphysis is healed. Healing of the head is well advanced. There is a hole in the outer third, and incomplete recalcification in the superior central portion.



FIG. 3-F

July 29, 1939. Hole in the outer third of the head is filled; the superior central part appears to be detached and displaced upward.

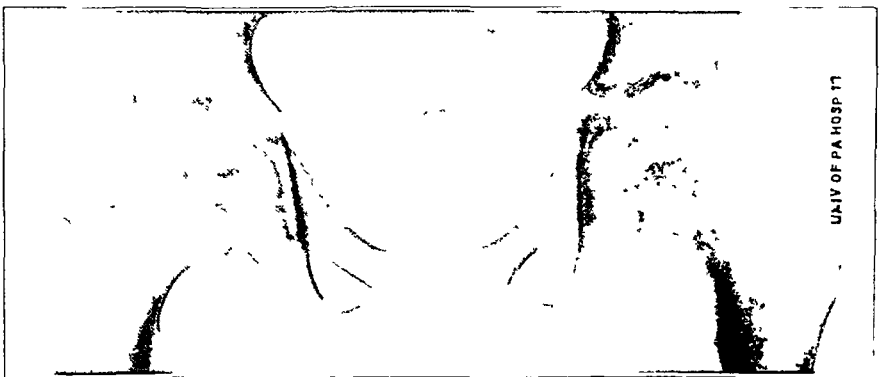


FIG. 3-G

March 2, 1940. Head is entirely healed except for superior central part, where the detached fragment seems to be united and not projecting upward. Head is round, not deformed, and does not project beyond the acetabulum. Neck is normal. The distance from the base of the greater trochanter to the top of the head is but one-eighth inch less than in the opposite hip.

the left leg two weeks later. This was relieved by rest, but returned on activity. He had pain in the left knee which became worse. The course of the disease is demonstrated in Figures 1-A to 1-I.

The first x-ray (Fig. 1-A) was taken four and one-half months after the onset of symptoms, but the pathological changes are only slightly evident. This presents a strong contrast to other cases in which marked necrosis of the neck and the head is evident as early as three weeks after the onset of symptoms. The degenerative phase of the cycle lasted for about one year. Note that the neck and metaphysis show the earliest evidence of healing, and that their regeneration is completed long before the regeneration of the head is completed or even well advanced. The phase of regeneration (Figs. 1-E to 1-I) had continued for nineteen months but was incomplete at this time. In the earlier x-rays (Figs. 1-A to 1-E) the head appears to stand away from the bottom of the socket (Waldenström's sign), but in the later x-rays (Figs. 1-F to 1-I) it has returned to approximately its normal position (Fig. 1-H). There is no appreciable deformity of the socket. The final x-ray shows but one-sixteenth of an inch shortening of the head and neck as measured from the top of the head to the inferior portion of the greater trochanter or to any other given point.

Case 2: W. C., male, aged six and one fourth years, was admitted to University Hospital May 4, 1937. He had had a limp for six weeks, with pain in the right knee for ten days after the limp was noticed. Both limp and pain disappeared with rest. He was treated by rest in bed with extension for thirteen months; then by brace with pelvic band and perineal crutch, high shoe, and crutches for another period of ten months. Tuberculin reaction was negative, and blood sedimentation rate normal. The course of the disease is shown in Figures 2-A to 2-I.

This case shows well-marked necrosis six weeks after the onset of symptoms, and the degeneration continued for twelve months after admission. Regeneration has progressed for sixteen months and is not complete. Note that Waldenström's sign (the size of the elliptical area outlined by the posterior margin of the acetabulum and the inner portion of the head and neck) is never so marked as in Case 1. Note also the increased size of the space between the head and the roof of the socket in the earlier x-rays (Figs. 2-A to 2-C). This is possibly due to the decalcification of the upper portion of the head, which makes it invisible. In the succeeding x-rays (Figs. 2-D to 2-I) this space becomes filled up by the regenerating head.

Case 3: R. E., female, aged seven years, was admitted to University Hospital November 2, 1936. She had had a limp for over one month which had been noticed by her school teacher. There was no pain. The tuberculin reaction was negative. She was treated by bed rest and traction for twelve months, and by brace, crutches, and high shoe for another ten months. This case is illustrated by Figures 3-A to 3-G.

This case showed marked advancement of disease when seen one month after the onset of symptoms. Degeneration continued for ten months more. Regeneration has been in progress for thirty months and is not altogether completed. Note that Waldenström's sign is very positive in

CASE 4. G. M. (Figures 4-A through 4-J)

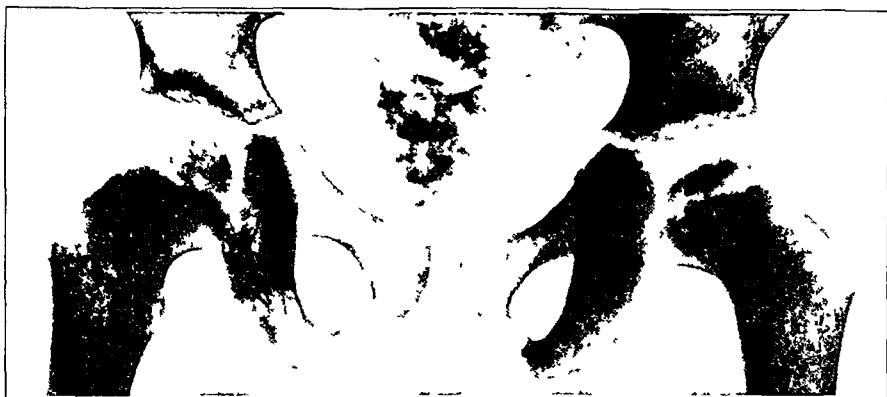


FIG. 4-A

September 10, 1937. Decalcification, extending irregularly across neck, is more marked in the inner two-thirds. Head shows marked degeneration, fragmentation, and is small and thin.



FIG. 4-B

November 20, 1937. There is an increase in the central necrosis of the metaphysis.



FIG. 4-C

April 1, 1938. Shows improvement in the metaphysis. Head has become very small and irregular.



FIG. 4-D

June 8, 1938. Continued definite recalcification of the metaphysis. Head has almost disappeared.

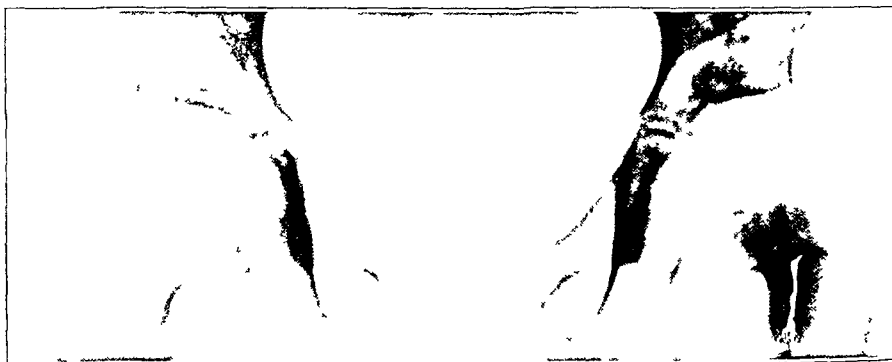


FIG. 4-E

August 23, 1938. Head is scarcely visible. Faint new calcification is appearing.



FIG. 4-F

November 4, 1938. Cycle has turned strongly upward.



FIG. 4-G

March 21, 1939. Regeneration is continuing.

CASE 4 (Continued)

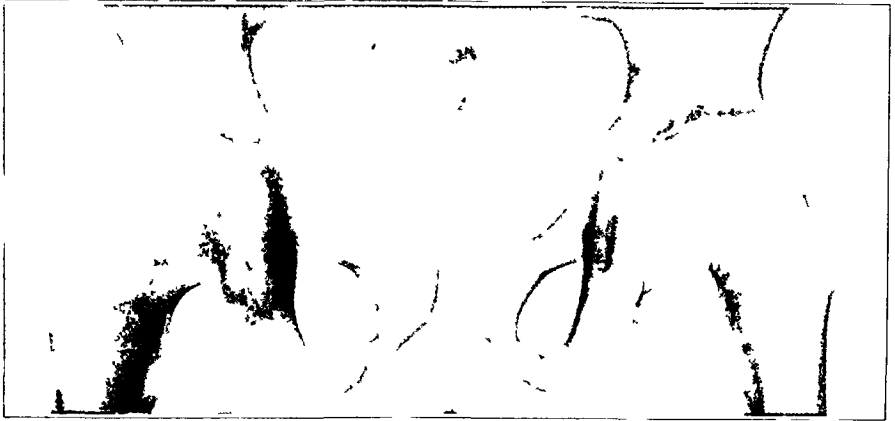


FIG 4-H  
June 24, 1939



FIG 4-I

October 6, 1939 Head is rebuilding and becoming rounded Metaphysis shows incomplete recalcification in the inner two-thirds



FIG 4-J

April 4, 1940. Regeneration is incomplete Head is thin, well rounded, and does not project beyond acetabulum Regeneration is incomplete in the inner half of the neck.

## CASE 5. D. B. (Figures 5-A through 5-E.)

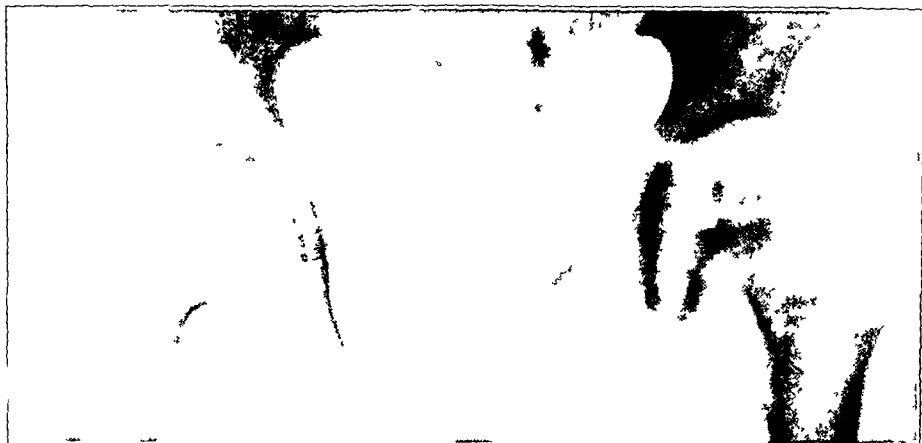


FIG. 5-A

November 8, 1938. Six months after onset of symptoms. Head is very small, rounded, and faintly visible. The metaphysis shows a large, rounded, central, cupped area of necrosis.

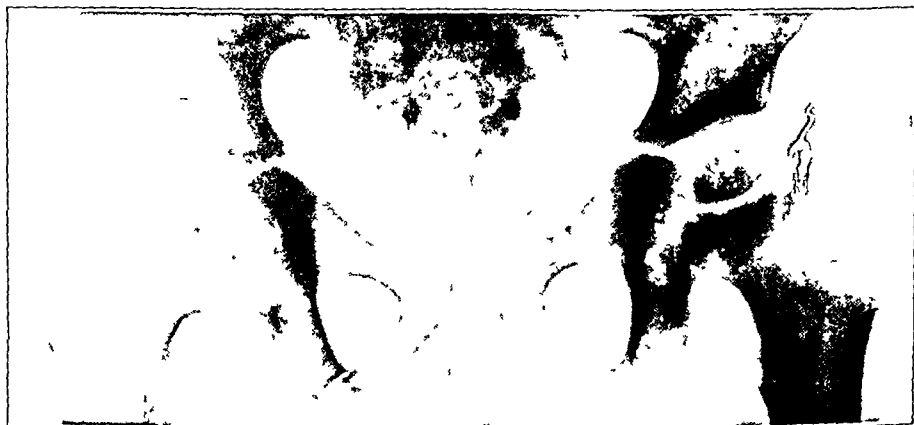


FIG. 5-B

March 8, 1939. Head is regenerating and enlarging.



FIG. 5-C

April 8, 1939. There is marked development of the head within a month, and regeneration in the metaphysis.

## CASE 5 (Continued)

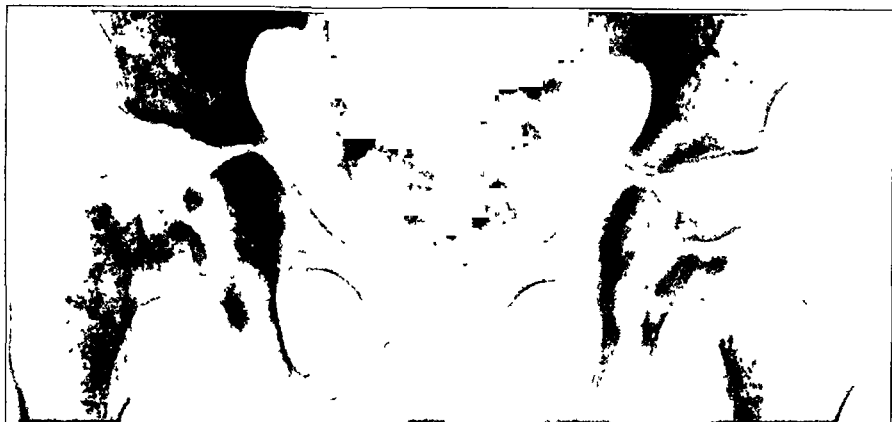


FIG. 5-D

August 25, 1939. Continued rapid regeneration.

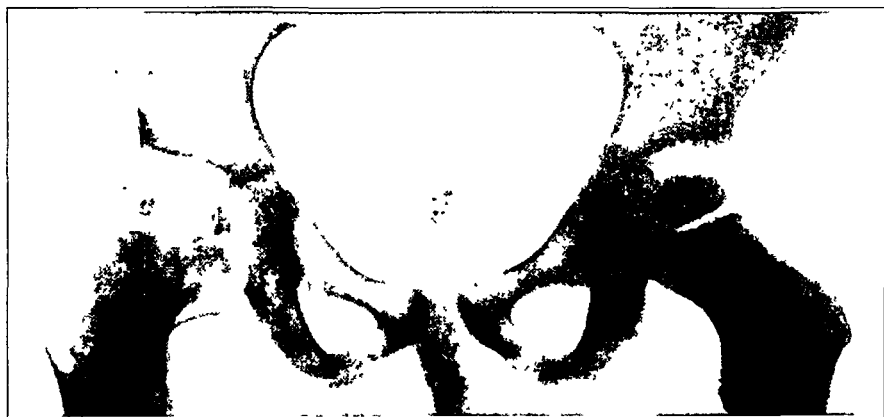


FIG. 5-E

February 12, 1940. Regeneration of head is incomplete. Metaphysis is almost healed. It is interesting to observe how well the head has reformed.

the earlier x-rays, but much less marked in the later ones. The final film does not show any thickening of the base of the socket or other deformity. As in all the other cases, the regeneration of the metaphysis is completed long before that of the head.

Case 4: G. M., male, aged three and one-half years, was admitted to University Hospital September 6, 1937. He had had pain and limp for six weeks. He was treated by bed rest and extension for nine months, with cast for four months, and then by high shoe and crutches. The course of the disease is shown in Figures 4-A to 4-J.

This case presents very marked degeneration six weeks after onset of symptoms. Degeneration continued for about twelve months. Regeneration, which has been in progress for seventeen months, is far from complete. Note that the metaphysis shows definite signs of recalcification while the decalcification of the head is continuing.

The following cases show unusual types of necrosis of the metaphysis.



FIG. 6-A

July 8, 1936 Shows marked necrosis of the inner and outer portions of the metaphysis with a central pillar of bone. Necrosis in head corresponds to that in the metaphysis



FIG 6-B

August 10, 1936 Shows lateral holes in the metaphysis.



FIG 6-C

November 13, 1936. Recalcification is beginning in the metaphysis, but head is degenerating



FIG. 6-D

February 9, 1937. Regeneration is beginning in the head.



## CASE 6 (Continued)

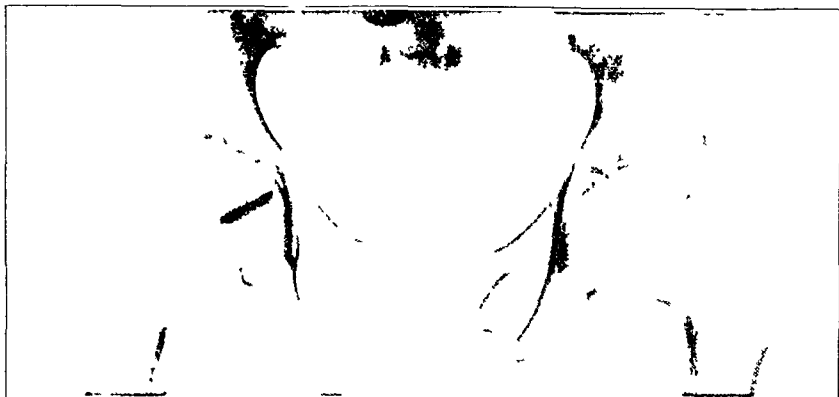


FIG. 6-E

May 10, 1937. Shows marked advance in regeneration.



FIG. 6-F

August 31, 1937. Regeneration is progressing as in other cases.



FIG. 6-G

June 20, 1939. Regeneration is incomplete twenty-eight months after it began. This case was treated by rest in bed for only eight months. This may be the cause of delayed regeneration and the evident deformity of the head and neck.

Case 5: D. B., male, aged three and one-half years, had in May, 1938, an upper respiratory infection and middle-ear infection. At the same time he had a limp and pain in the right leg. After rest in bed for three weeks the pain disappeared but the limp continued. Course of the disease is shown in Figures 5-A to 5-E.

The examination of the first film (Fig. 5-A) caused much discussion. Was it true Legg-Perthes disease or was it the result of a definite infection that occurred when the child had an infection of the middle ear six months before? Gross infection of the hip joint or an infectious epiphysitis was ruled out by the facts that there was but slight limitation of motions, and but very slight thickening through the hip. Both these signs conformed to Legg-Perthes disease, and this diagnosis was made, largely by careful palpation. The blood sedimentation rate was normal. Four months later (Fig. 5-B) there was definite evidence of marked recalcification in the metaphysis, and beginning recalcification in the head. This was but ten months after the onset of symptoms. It suggested that the necrosis began long before the onset of symptoms, or that it progressed more rapidly than usual. Note how the space between the head and the roof of the socket is large in the earlier x-rays, but that it becomes occupied by the regenerating head in the later x-rays. Again the regeneration of the metaphysis precedes that of the head.

Case 6: W. O'B., male, aged five years, had limp and pain for three months before admission on July 7, 1936. This case is illustrated in Figures 6-A to 6-G.

This case shows clearly how the lateral necrosis of the metaphysis is accompanied by corresponding necrosis in the head, and how the last visible portion of the head sits upon a central pillar of bone in the metaphysis. It also illustrates the increased length of the regenerative phase of the cycle which is probably due to the absence of proper treatment by prolonged rest. The residual deformity is also probably due to the same cause.

Case 7: W. P., male, aged seven years, had pain in the hip for one year before the first examination, June 8, 1938. This case is shown in Figures 7-A to 7-D.

This case illustrates a very marked and widespread necrosis in the neck even down to its base. The rather marked deformity (Fig. 7-D) is probably due to the fact that treatment was not begun until one year after the onset of symptoms.

Case 8: S. P., male, aged four years, had pain for three weeks before admission to University Hospital on April 29, 1930. Tuberculin and Wassermann reactions were negative. This case is illustrated in Figures 8-A to 8-C.

This case is interesting because it shows a central conical-shaped necrosis in the metaphysis and neck. It is suggestive of thrombosis of a central vessel. Note how marked are the pathological changes evident within three weeks after the onset of symptoms.

Case 9: R. T., male, aged nine years, was of the Fröhlich's-syndrome type. Three weeks before first examination on July 20, 1939, he had jumped down six feet from a wall,

CASE 7. W P (Figures 7-A through 7-D )



FIG 7-A

June 8, 1938 Shows necrosis of a large part of the neck



FIG 7-B

October 5, 1938 Shows large necrotic area in the neck



FIG 7-C

January 5, 1939 Head and neck are regenerating



FIG 7-D

May 16, 1939 Metaphysis and neck have recalcified Head is regenerating well.

## CASE 8. S. P. (Figures 8-A through 8-C.)

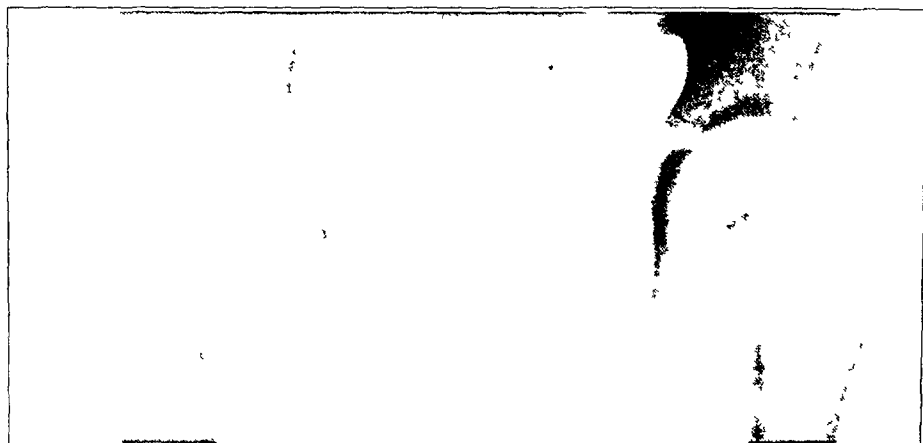


FIG. 8-A

May 6, 1930. Shows conical necrosis in the neck.

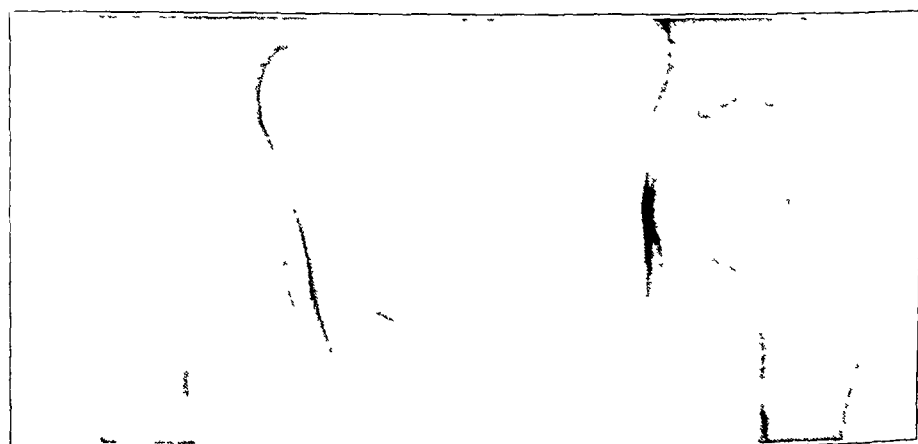


FIG. 8-B

October 3, 1930. This resembles an infarct.



FIG. 8-C

May 7, 1931. Shows partial healing in the neck, but continued disintegration of the head.

CASE 9. R. T. (Figures 9-A through 9-D.)

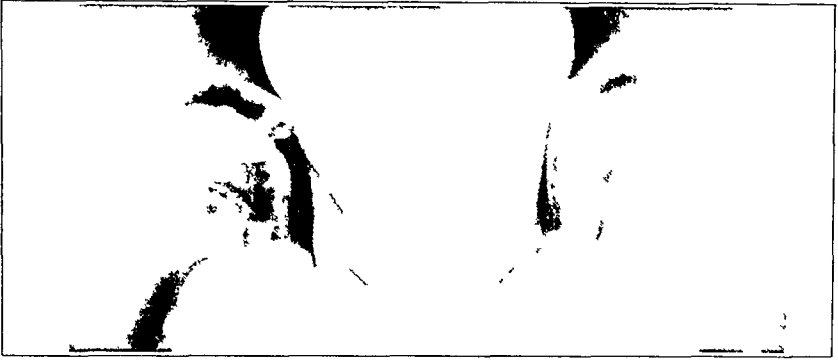


FIG 9-A

July 20, 1939. Broad faint band of decalcification extends entirely across the upper part of the neck. Head is slightly smaller and slightly decalcified.

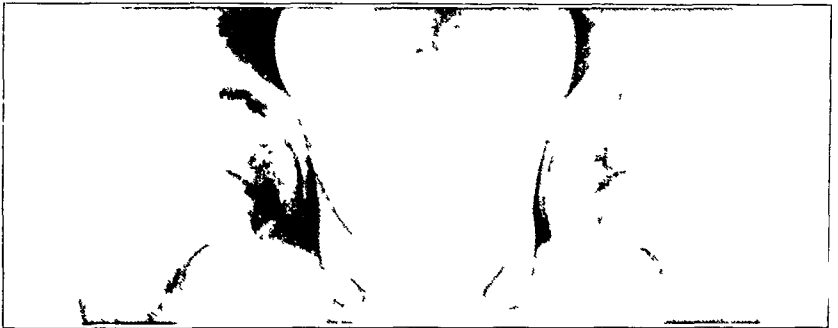


FIG. 9-B

November 25, 1939. Shows marked necrosis extending across the upper half of the neck. Head is more dense.

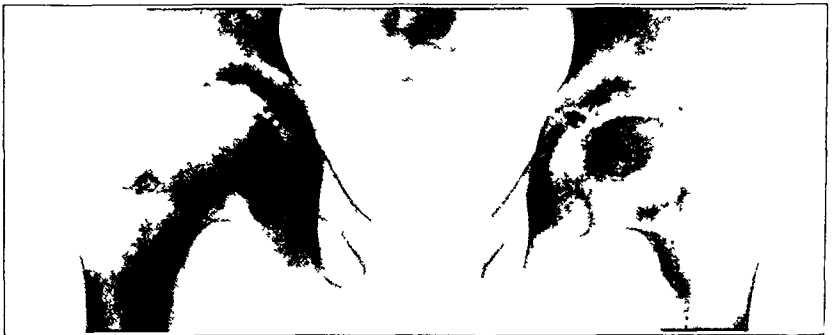


FIG. 9-C

December 27, 1939. A necrotic band involves large part of neck.

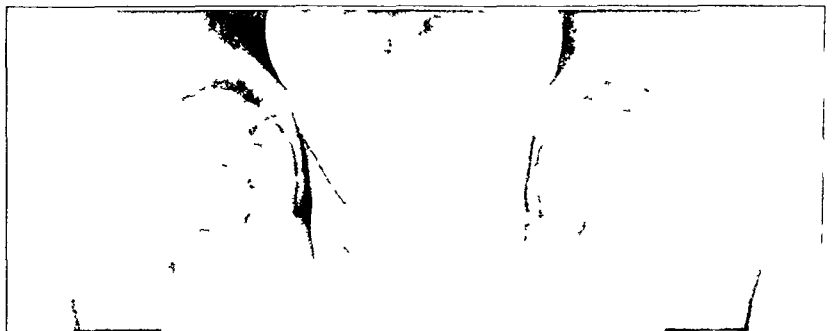


FIG. 9-D

April 11, 1940. Shows marked and rapid healing in the neck, but progressive disintegration of the head.

## CASE 10 B F (Figures 10-A through 10-F)



FIG. 10-A

October 14, 1939 There is a band of necrosis across the entire metaphysis. Head is slightly smaller, with decalcification of the outer third.

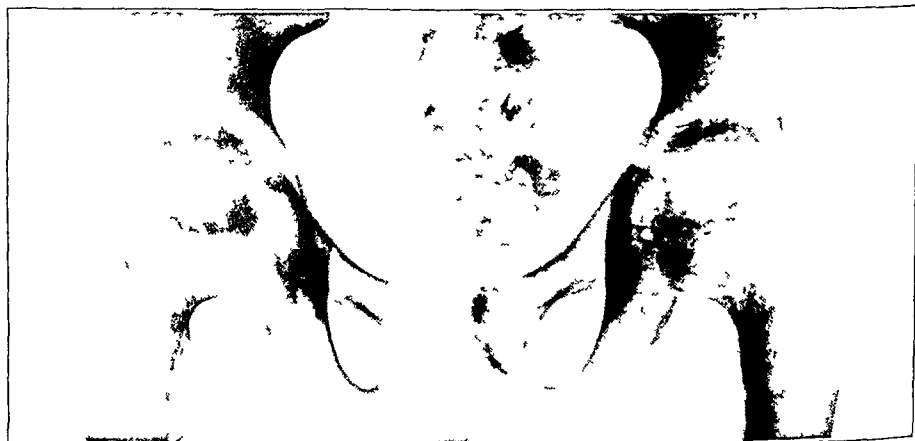


FIG. 10-B

December 27, 1939 Shows a marked advance in necrosis of the neck and outer portion of the head.



FIG. 10-C

January 8, 1940. A different view showing marked destruction of the neck.

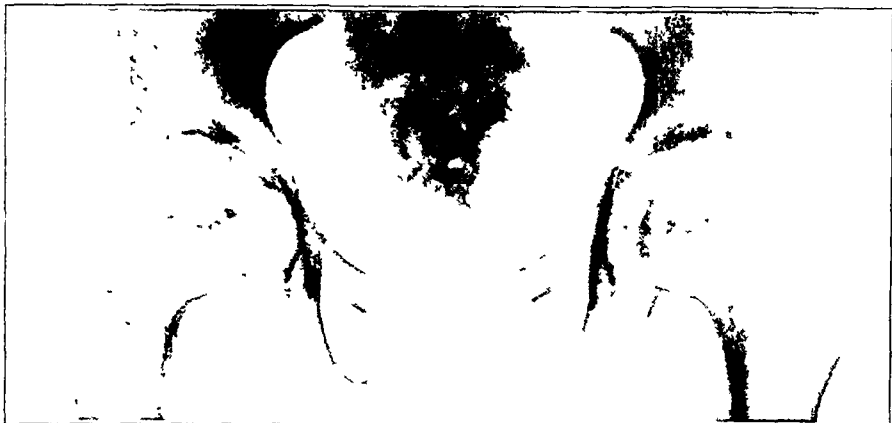
CASE 10 (*Continued*)

FIG. 10-D  
March 1, 1940.



FIG. 10-E  
March 1, 1940.



FIG. 10-F

April 11, 1940. Appears to show the beginning of healing in the neck, though outer portion of the head has disappeared.

## CASE 10. B. F. (Figures 10-A through 10-F.)



FIG. 10-A

October 14, 1939. There is a band of necrosis across the entire metaphysis. Head is slightly smaller, with decalcification of the outer third.

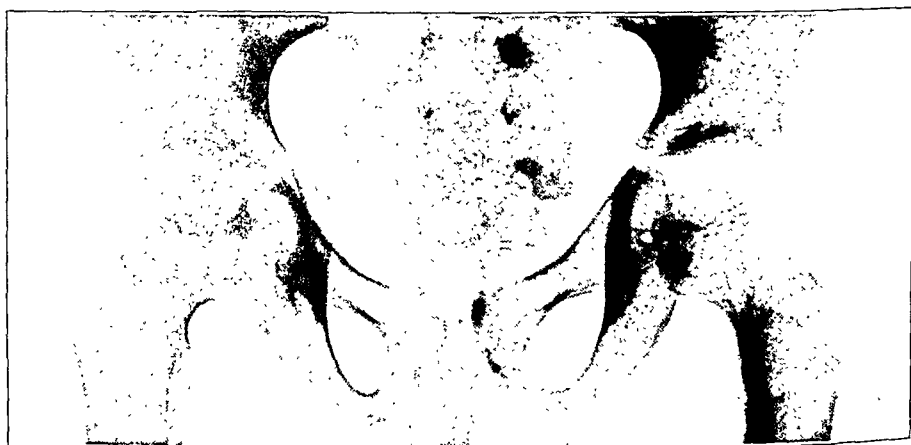


FIG. 10-B

December 27, 1939. Shows a marked advance in necrosis of the neck and outer portion of the head.



FIG. 10-C

January 8, 1940. A different view showing marked destruction of the neck.



CASE 11. B. M. (Figures 11-A and 11-B.)



FIG. 11-A

August 31, 1938. Early slipping of the epiphysis. Note area of necrosis in metaphysis and the very slight displacement of the head.

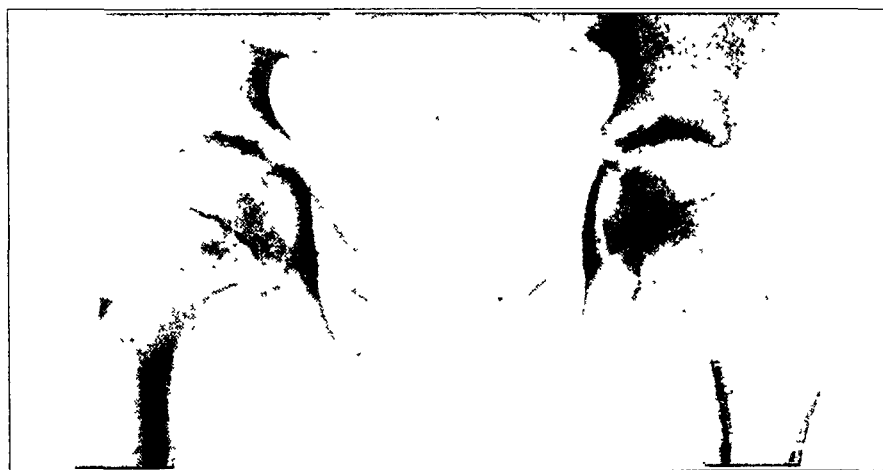


FIG. 11-B

August 31, 1938. Same as Fig. 11-A, but the film is slightly overexposed. Note how the area of necrosis stands out more clearly than in Fig. 11-A.

with resulting pain in knee; a limp developed. Tuberculin reactions were negative, and blood sedimentation rate was normal. The course of the disease is shown in Figures 9-A to 9-D.

This case illustrates the broad bandlike necrosis in the metaphysis and neck which is evident three weeks after the onset of symptoms. The necrotic process progressed for about six months in spite of absolute rest in bed with Buck's extension. Then suddenly regeneration began in the neck.

Case 10: B. F., male, aged seven years, had had a limp for four months, but no pain. Tuberculin reaction was negative. There was a slight firm thickening, but no swelling or tenderness. The case is shown in Figures 10-A to 10-F.

## CASE 12. A. D. (Figures 12-A through 12-E.)



FIG. 12-A

October 10, 1934. Shows a bloodless reduction. Head is small and fragmented. There is no evidence of necrosis of the metaphysis.



FIG. 12-B

October 10, 1935. Head appears smaller.

If Case 9 and Case 10 are thought to be examples of slipped epiphysis, they should be compared with the following case.

Case 11 B. M., male, aged ten years, was admitted to University Hospital August 31, 1938, with a typical history and x-ray appearance of a slipping epiphysis. The hip became healed in six to eight months without deformity of the head. See Figures 11-A and 11-B.

Necrosis of the metaphysis is apparently the cause of slipping of the epiphysis. This necrosis appears to be similar to that seen in Legg-Perthes disease (Cases 9 and 10), but it is not accompanied or succeeded by similar changes in the head. The phase of healing in epiphysiolysis occupies a much shorter time than in Legg-Perthes disease. A close inspection of the head (Fig. 11-B) with a magnifying lens appeared to show

CASE 12 (*Continued*)

FIG. 12-C

September 24, 1936. Head is fragmented, but larger. There is no necrosis in the metaphysis.



FIG. 12-D

October 4, 1937. Note the very slow development of the head within the past year.



FIG. 12-E

February 2, 1940. Shows incomplete development, and deformity of head five years after Fig. 12-A.

## CASE 13. A. W. (Figures 13-A through 13-G.)



FIG. 13-A

May 25, 1935. Shows marked changes in the left hip, early ones in the right. Symptoms were present in the left hip for six weeks, none in right.

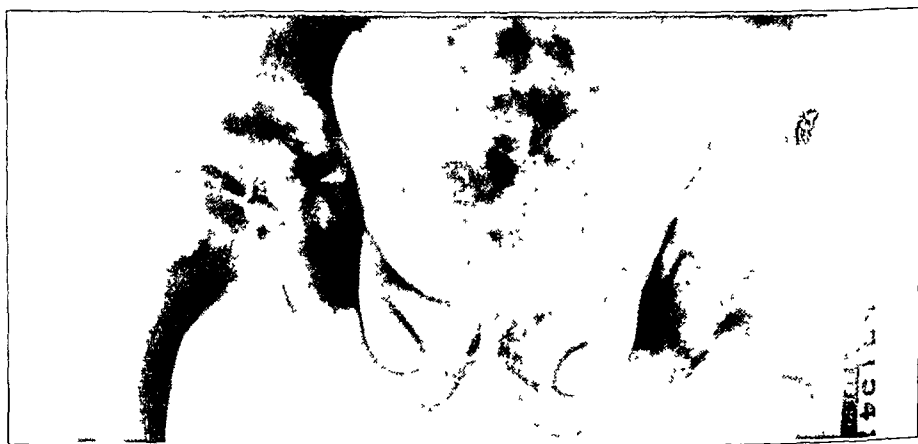


FIG. 13-B

February 28, 1936. Patient has been untreated. Very little change has occurred in the left hip since the preceding film. There is a marked advance of the disease in the right hip. Note central necrosis in the neck.



FIG. 13-C

April 28, 1936. Shows evidence of "shelf" operation on the right hip five weeks previously.

CASE 13 (*Continued*)

FIG. 13-D

November 18, 1936. Shows marked deformity of the head, neck, and acetabulum of the left hip (untreated). "Shelf" encloses the right head.



FIG. 13-E

June 22, 1938. Head of the right femur remains in the reconstructed (enlarged) socket.



FIG. 13-F

June 22, 1938. Same as Fig. 13-E, but with legs abducted.

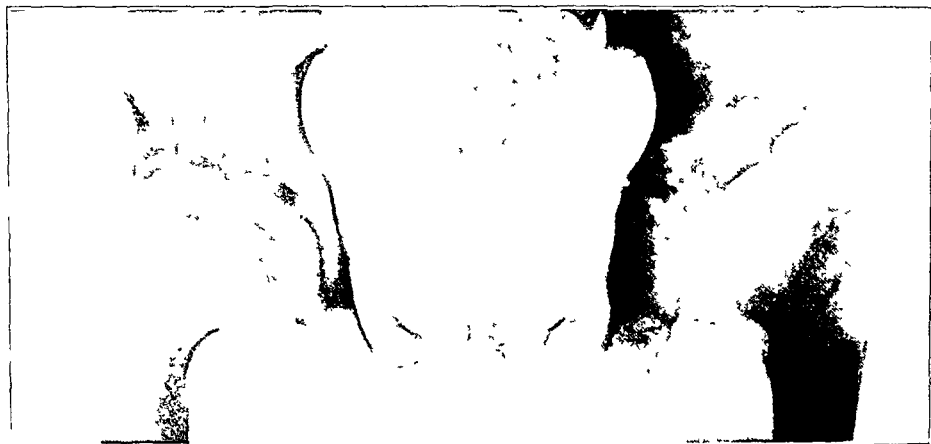
CASE 13 (*Continued*)

FIG. 13-G

January 7, 1939. Shows marked deformity and subluxation of the left hip, sufficiency of the right acetabulum, and less marked deformity three years after "shelf" operation.

very slight evidence of decalcification, but five months later this had disappeared. One can readily conceive that in Cases 9 and 10 the head would have slipped if early treatment had not been instituted. The similarities between Legg-Perthes disease and slipping epiphysis are interesting and will be worthy of further study.

Case 12: A. D., female, aged two years, had congenital dislocation of the hip.

This case illustrates the difference between true Legg-Perthes disease and the somewhat similar condition that frequently is a sequel to congenital dislocation. See Figures 12-A to 12-E.

Case 13: A. W., male, aged ten years when first examined, had symptoms in the left hip of six weeks' duration, but no symptoms in the right. See Figures 13-A to 13-G.

This case illustrates the course of a case not treated by rest, and shows the advantage of the "shelf" operation to make a socket that completely contains the head and gives stability. The right hip did not progress to the marked degree of deformity shown in the left.

## SUMMARY

1. Legg-Perthes disease is an affection of the head and neck of the femur which runs a cyclical course. The first, or degenerative, phase of the cycle extends through a period of approximately a year and a half. The second, or regenerative, phase requires two to three years for its completion. Adequate treatment by prolonged non-weight-bearing shortens the cycle, and absence of such treatment prolongs it.

2. The etiology is as yet unproved. The age incidence, in the author's cases, has been between three and eleven years and 85 per cent. have been boys (just the reverse of the sex incidence of congenital

dislocation). Tuberculin reactions have been consistently negative, and the blood sedimentation rate has been normal.

3. The usual symptoms are limp, and pain which is more commonly felt at the knee. The disease is often far advanced at the onset of symptoms.

4. The physical signs are limitation of motion (particularly of rotation) and a slight, but definite, firm thickening of the hip. Occasionally there is slight wasting of the muscles of the thigh.

5. The pathological process is essentially one of aseptic necrosis of the neck and head of the femur which is succeeded by a physiological process of repair.

6. The necrosis is always evident in the metaphysis, and the study of early cases indicates that here is the primary location of the disease. Necrosis of the head follows, and the primary area in the head corresponds exactly to the primary area in the metaphysis. As the disease spreads in the metaphysis, corresponding changes occur in the remainder of the head.

7. Healing occurs first in the metaphysis and later in the head. The corresponding part in each which was the first to show evidence of necrosis is the first to repair.

8. These observations indicate that the disease is essentially one which produces a progressive destruction of the blood supply through the metaphysis and the epiphyseal plate of cartilage, and that the changes which occur in the head are secondary to those in the neck.

9. The deformities that arise in the head and the neck are due to a mechanical crushing of the necrotic tissue caused by weight-bearing and muscle pull. Deformity of the acetabulum is dependent upon the altered shape and position of the head.

10. Treatment by rest in bed with Buck's extension leads to such complete restoration that in the final result it is difficult to detect any deformity of head, neck, and acetabulum.

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CAVANAUGH, L. A.; SHELTON, E. K.; AND SUTHERLAND, ROSS: Metabolic Studies in Osteochondritis of the Capital Femoral Epiphysis. *J. Bone and Joint Surg.*, XVIII, 957, Oct. 1936.

# GROWTH FOLLOWING FUSION FOR TUBERCULOSIS OF THE KNEE IN CHILDREN

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Considerable discussion has arisen regarding the surgical treatment of tuberculosis of the knee in children. One of the arguments against treatment of tuberculosis of the knee joint in children by fusion or resection is the possible loss of growth in the extremity. As about 65 per cent. of length growth takes place at the epiphyseal cartilage plates adjoining the knee joint, there is reason for careful consideration before undertaking operative interference in a growing child. If the epiphyseal cartilage plates of both the lower end of the femur, and the upper end of the tibia are destroyed, there may be a loss of from five to six inches on the affected side.

From the results of experimental resection of knee joints<sup>1</sup> it has been shown that, after the careful resection of the articular cartilage and a layer of cancellous bone, there may be no loss of growth. It was emphasized that the epiphyseal cartilage plate must not be injured during the resection, and the adjoining layer of cancellous bone should be preserved. Since the mechanism of length growth of bones is the same in humans as in animals, one would anticipate that, if the same care were utilized in the operative procedure in man as in the experiments on animals, there would be no growth disturbance from the operation of resection of joints for tuberculosis.

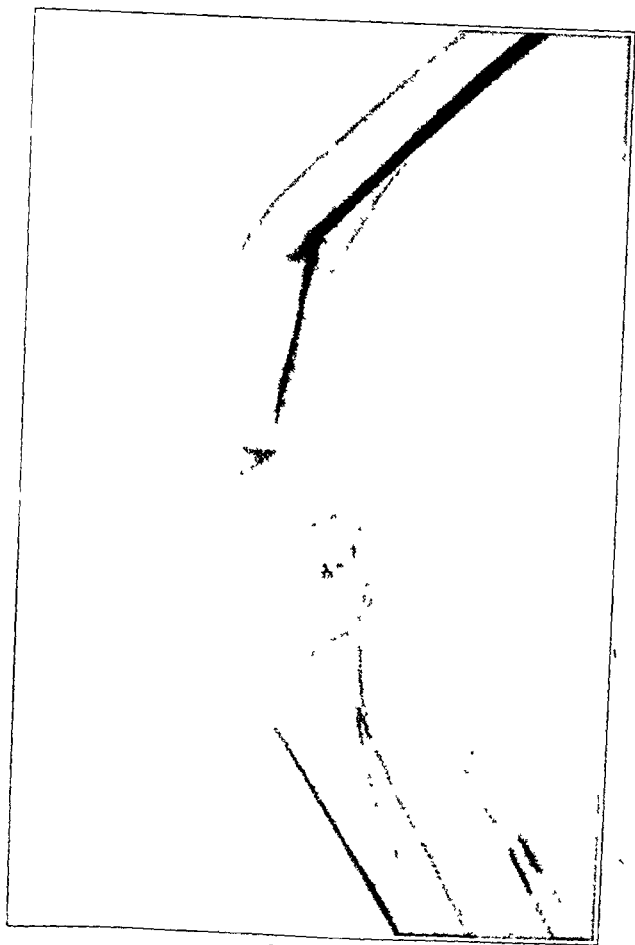


FIG. 1

Case 7. E. G. Roentgenogram, February 1, 1934.  
Knee joint before operation.



TABLE I  
RÉSUMÉ OF TWELVE CASES SHOWING GROWTH FOLLOWING FUSION FOR TUBERCULOSIS OF THE KNEE

No	Name	Age (Years)	Family History of Tuberculosis	Dura- tion (Years)	Operations *	Tuberculin Test	Guinea Pig Test	Micro- scopic Examina- tion	Time Re- quired for Union	Postoperative Shortening	Obser- vation Time (Years)
1	G. B.	2 $\frac{3}{4}$	Grandfather	1	Nov. 9, 1931 (Exploration) Aug. 7, 1933	Positive (Human and Bovine)	Positive	Positive	2 years and 3 months	Less than $\frac{1}{2}$ inch	4
2	E. Q.	4 $\frac{1}{4}$		2	Mar. 16, 1934 Jan. 13, 1936 Sept. 24, 1937	Positive **	Positive	Positive	2 years and 6 months	None	8
3	H. E.	4 $\frac{1}{2}$		2 $\frac{1}{2}$	Mar. 16, 1936 Dec. 13, 1938	Positive +++		Positive	2 years	None ( $\frac{1}{2}$ inch lengthening)	4
4	I. M.	5	Father	2	May 1, 1935 Mar. 24, 1937	Positive ** +++	Positive	Positive	3 years	None ( $\frac{1}{2}$ inch lengthening)	
5	H. D.	5 $\frac{1}{2}$	Father	4 $\frac{1}{2}$	Jan. 30, 1933 (Exploration) Oct. 24, 1934 †	Positive (Bovine) +	Positive	Positive	Fibrous	None	2
6	G. G.	6		4	July 25, 1930			Positive	3 years	None	7
7	E. G.	8		5	Mar. 14, 1932 (Curettement) Nov. 14, 1934	Positive **		Positive	2 years	$\frac{3}{8}$ inch	3
8	L. R.	8		6	Nov. 13, 1935 Nov. 15, 1937	Positive ** ++		Positive	2 years and 8 months	$\frac{1}{4}$ inch	4
9	S. G.	11		5	July 1, 1935				9 months	None	2
10	R. H.	11		10	July 12, 1933	Positive (Human) +++	Positive	Positive	10 months	None	3
11	C. G.	11 $\frac{1}{2}$		10 $\frac{1}{2}$	Feb. 15, 1932 Dec. 6, 1933	Positive (Human and Bovine)	Positive	Positive	1 year	$\frac{1}{2}$ inch	2
12	W. W.	12 $\frac{1}{2}$		8	Apr. 13, 1936	Positive ** +++		Positive	4 months	None	1 $\frac{1}{2}$

\* All operations were for resections except where designated.

\*\* Stock preparation used.

† On January 11, 1935, the patient died at home, presumably of meningitis. Normal healing had taken place in the joint.

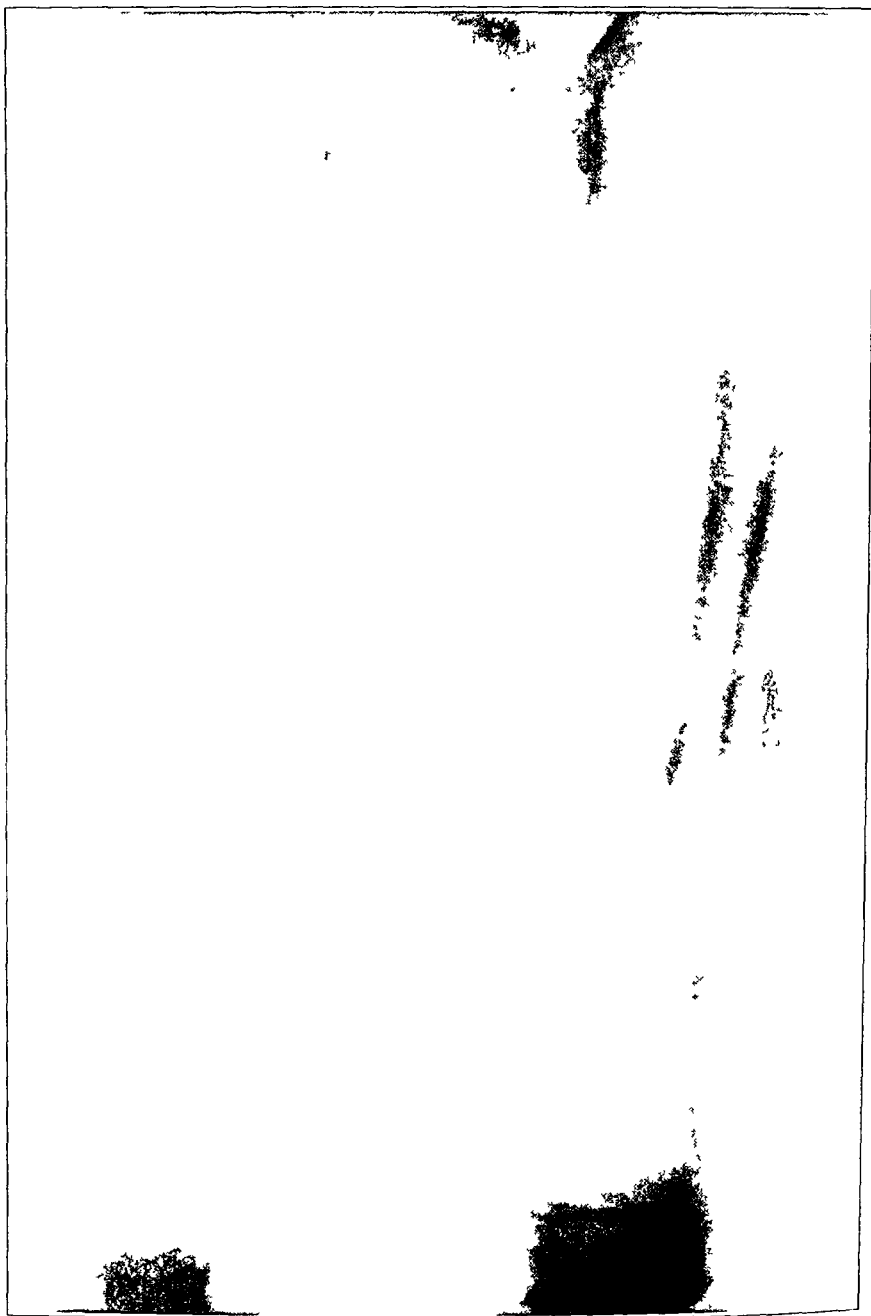


FIG. 2

Case 7. E. G. Roentgenogram, taken November 12, 1936, two years after operation, shows the operated femur one-quarter inch longer than the normal. Notice fusion of tibia and femur.

Because of the importance of this problem, it is worth while to study the results of operative treatment, especially if the idea is accepted that only after ankylosis, or the prevention of motion, is a cure of bone tuberculosis almost certain.

At the Shriners' Hospital in San Francisco the author had only a small

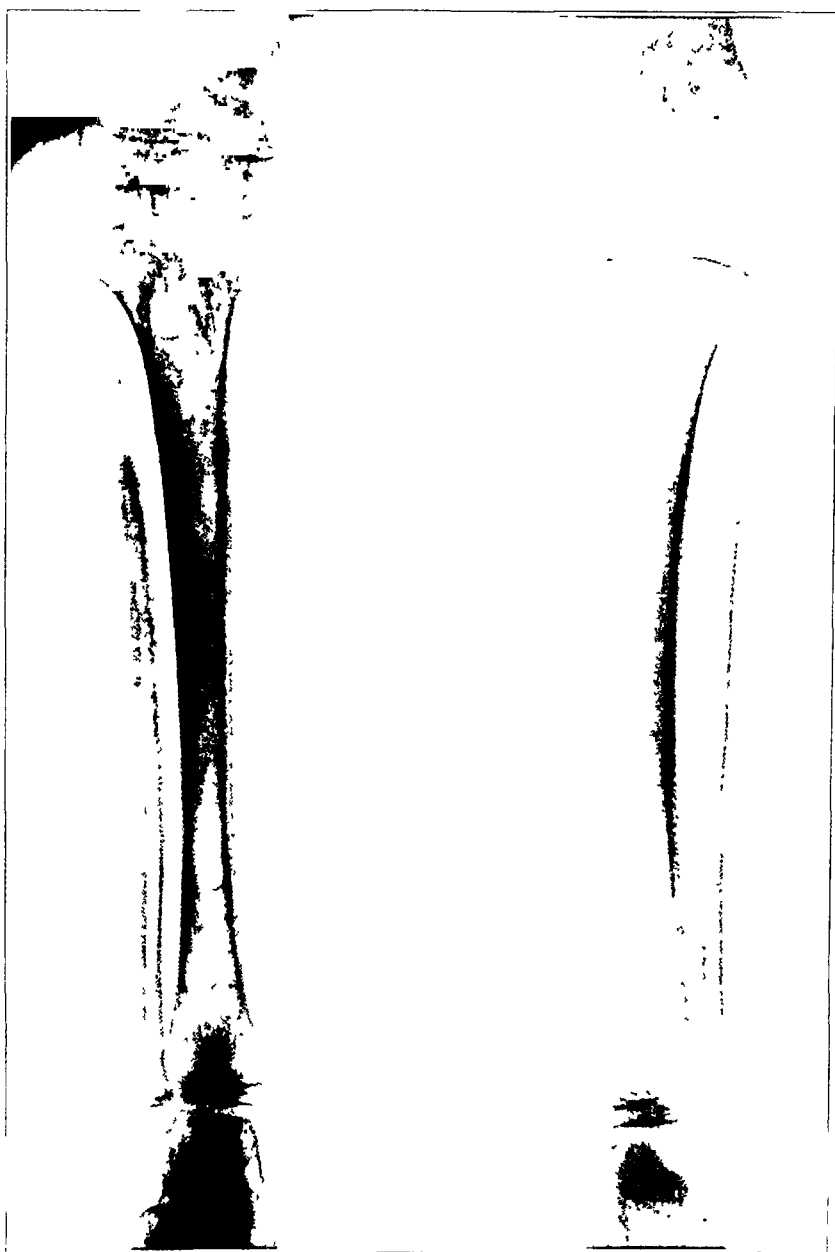


FIG. 3

Case 7. E. G. Roentgenogram, taken November 12, 1936, two years after operation, shows that the operated tibia is five-eighths of an inch shorter than the normal.

series of cases of tuberculosis of the knee joint treated by operative fusion. He had, however, an opportunity of observing these patients over a fairly long period of time, with a follow-up of careful measurement, mostly from roentgenograms. The age of the patients at the time of operation covered a representative range from two and three-quarters years

up to twelve and one-half years, and should, therefore, serve as a basis for some valuable conclusions. It is hoped that this short series, added



FIG. 4



FIG. 5

Case 2. E. Q. Front and side views. Fig. 4 shows condition before operation and Fig. 5 two years after fusion of the knee joint. Notice that the lower extremities appear equal in length.

to other reports, will help to answer the questions of the advisability or inadvisability of operative treatment of knee-joint tuberculosis in children.

The operations were performed with a tourniquet through a lateral or medial patellar approach. Whenever possible, the patella was preserved, and, after denuding its undersurface of cartilage, it was transferred to the resected region. After exposing the diseased joint, the remaining articular cartilage of the femur and tibia was removed with as much of the diseased tissue as possible. Particular care was taken to keep away from the epiphyseal cartilage plates of both the femur and the tibia. It was thought better to leave a little diseased tissue, if it extended near the plate, than to remove it, even though another operation might be necessary to secure osseous union. In the very young, where there was a preponderance of cartilage and the ossification center of the epiphysis was small, it was advisable to remove only a thin layer of cartilage, even, though a fibrous union might occur. Later, with increased growth of the ossification center it was possible to perform a second operation and secure bony union. In some cases where there was an extreme flexion deformity, a preliminary,

partial correction of the deformity by wedged plaster and other means was carried out. After operation, wherever possible, the limb was placed in a position of extension, because there was the usual tendency for flexion deformity to take place with further growth and overaction of the flexor muscles. The patients were kept in plaster until firm union was secured. Afterward, as an added precaution, they were usually provided with a brace with a molded leather knee cage to be worn for another year.

There were twelve cases in this series of knee fusion in children. The important facts and the results are shown in the table. Figures 1, 2, and 3 are roentgenograms of Case 7 and Figures 4 and 5 show preoperative and postoperative photographs of Case 2.

#### SUMMARY

The age range of the patients extended from two and three-quarters to twelve and one-half years. In at least three of the patients there was a family history of pulmonary tuberculosis. The duration of the disease varied from one to ten years, being of greater duration in the older patients. The tuberculin test, guinea-pig test, and microscopic findings were fairly uniform at the time of operation; and it is of interest that they were positive even in the older patients. It usually required two operations before a firm, osseous ankylosis took place. It required a longer period in the younger patients than in the older to secure ankylosis. The average time required for bony union in all the patients was about two years. There was no loss of growth in the majority of the patients, and when it did occur it was not more than one-half inch. In some of the patients there was a lengthening after operation due to stimulation of the epiphyseal cartilage plate.

#### CONCLUSIONS

Arthrodesis of the knee joint for tuberculosis can be successfully performed in growing children as young as two and three-quarters years, without any loss of growth. Care must be utilized not to injure the epiphyseal cartilage plate. Adequate protection to prevent flexion deformity must be provided for several years after operation.

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# MALUNION OF FRACTURE OF THE HEAD OF THE METACARPAL BONE (KNUCKLE FRACTURE)

## A SIMPLE OPERATION FOR CORRECTION

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Although commonly regarded as a trivial injury, "knuckle fracture" may still disable an individual and place before the experienced orthopaedic surgeon a most perplexing task. The difficulties encountered in the treatment of knuckle fractures have been duly emphasized in numerous medical publications by Cotton, Jahss, Jones, Magnuson, and others. The surgical management of knuckle fracture with malunion presents even greater complexities. Reports of such cases are excessively difficult to find.

The purpose of this paper is to review briefly the regional anatomy, to present the pathology of knuckle fractures experimentally produced in cadavera, with comments on their etiology; and to report a case with malunion successfully operated on by a method which the author has not seen described heretofore.

### ANATOMY

A metacarpophalangeal joint has no true fibrous capsule, but is invested by a tube of synovial membrane which lines the volar, and the two collateral ligaments. Proximally, the synovial membrane cloaks the neck of a metacarpal bone and forms a dorsal and a volar fold. These folds are comparable to the plica of a tendon sheath, and extend the joint space approximately an inch above the terminal articular surface. Between the dorsal extensor tendon and the synovial roof there is a space normally filled with a very loose areolar tissue. This makes possible the wide excursion of motion of the extensor expansion as it glides over the synovial membrane and smooth dorsal angle of the metacarpal bone.

### PATHOLOGY

In knuckle fractures, experimentally produced in cadavera, the skin and dorsal extensor tendon displayed some evidence of trauma. The synovial roof was intact in some instances; in others, one to three small rents were found. These rents were due to the jagged ends of the shaft fragment, sometimes seen protruding through the openings. Dorsally, the fracture was invariably within the joint. Volarly, however, the oblique fracture line was cloaked by the synovial membrane. The distal fragment with its uninjured articular surface and intact collateral ligaments was displaced into the palm laterally and toward the wrist, with a

\* Service of H. Finkelstein, M.D.



FIG. 1

Roentgenograms showing fracture of the second, third, fourth, and fifth metacarpal heads experimentally produced in cadavera. Note injected vessels.

resultant shortening of the metacarpal bone and increase in its antero-posterior and transverse diameters. There was fragmentation of the neck but no real impaction. Proximal to the area of fragmentation, there was the jagged end of the metacarpal shaft (Fig. 1).

#### ETIOLOGY

Although there have been no experimental determinations on their relative strengths, we know that the metacarpal bones vary in dimension. They gradually diminish in size from the second which is the largest toward the little finger. It seems quite reasonable to conclude, therefore, that the fifth metacarpal is most susceptible to trauma and the second the least.

According to the anatomical texts, flexion is limited at an angle of about 70 degrees. However, upon examination, it will be noted that the fifth finger flexes more than the fourth, and both exceed either the second or the third. Thus, the head of the fifth metacarpal is more readily accessible to injury than the fourth, and both more so than the second or third.



FIG. 2

Preoperative roentgenograms of a malunited fracture of the head of the fifth metacarpal bone. In the anteroposterior view the distal articular fragment is displaced toward the fourth metacarpal, and the jagged end of the proximal fragment is displaced ulnally, causing an increase in the transverse diameter of the head and a resultant soft-tissue prominence on the ulnar side of the hand (see arrows). In the lateral view the distal fragment is displaced into the palm and toward the wrist, with shortening of the head, and an increase in its anteroposterior diameter, causing a soft-tissue prominence in the palm (see arrow). There is a minimum of change in the relationship between the axis of the articular surface of the head and the axis of the shaft of the fifth metacarpal bone. The surfaces of the metacarpophalangeal articulation are intact. Dorsally, the jagged end of the shaft fragment is seen within the joint cavity.

Roberts reports, in 200 knuckle fractures there were 120 involving the fifth; twenty, the fourth; sixteen, the third; and forty-four, the second. This emphasizes the importance of trauma. While the second metacarpal may be stronger and less accessible than the rest, it is traumatized more often than the third or the fourth, but not so often as the fifth.

Experimental evidence tends to show an architectural variation among different individuals rather than a varying of the metacarpals in the same individual. When the architecture of the metacarpals is such that the necks are weaker than the bases, knuckle fractures occur; when the bases are weaker, base fractures occur. Therefore, some persons have a special predilection to knuckle fractures, others to base fractures. The volar articular ridges of the metacarpal heads act as reinforcements and very likely account for the obliquity of the fracture line so characteristic of knuckle fractures.

Ossification also plays a rôle in the incidence of knuckle fracture. During the growth period, until the epiphyses unite with the bodies at



about the end of the twentieth year, the metacarpal bones are probably more susceptible to fractures. Ossification is first to appear and union first to occur in the second metacarpal bone. This may also be of some importance in the occurrence of fracture.

#### REPORT OF CASE

V. C., a white adult male, aged twenty-two, came to the author May 14, 1936. The patient stated that he had broken the knuckle of the fifth finger of the right hand on November 2, 1934. He complained of a bony prominence in the palm with a weakness of his right hand. The little finger was always in the way, and the patient was constantly striking it against various objects.

Physical examination revealed a prominence of the shaft of the fifth metacarpal dorsally and toward the ulnar side of the hand. The head of the fifth metacarpal was prominent in the palm, and, together with the proximal phalanx, was displaced toward the fourth. Motion at the metacarpophalangeal joint was confined to an arc of about 10 degrees; angle of greatest extension, 175 degrees; angle of greatest flexion, 165 degrees. Extension seemed to be limited by a bony impediment, and flexion by soft-tissue structure. There was loss of power in flexion of the ring and middle fingers. The index finger was unimpaired. X-rays revealed a fracture of the neck of the fifth metacarpal with malunion (Fig. 2).

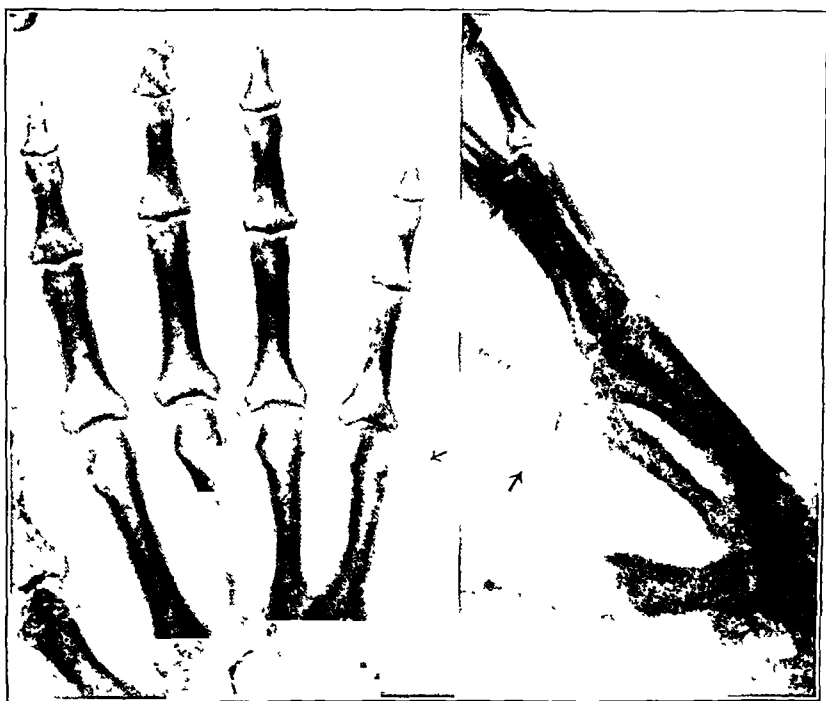


FIG. 3

Postoperative roentgenograms show the leveling off of the dorsal and ulnar bony-shaft prominences with restoration of a more normal articular contour of the head of the fifth metacarpal bone. The anteroposterior and transverse diameters of the bone have been reduced, and the palmar and ulnar soft-tissue shadow prominences have disappeared (see arrow). Thus a more normal relationship has been established between the fifth metacarpal bone and the flexor and extensor tendons.

*Operation:*

Through a simple longitudinal incision over the dorsomedial aspect of the fifth metacarpophalangeal joint, the dorsal extensor tendon was found overlying and adhering closely to a dense fibrous-tissue mass. The fibrous-tissue mass, almost fibrocartilaginous in character, adhered closely to the underlying metacarpal bone and synovial membrane of the joint, and obliterated the space, previously referred to, normally filled with loose areolar tissue. This fibrous-tissue mass was a definite barrier to flexion of the finger.

On separating the fibrous-tissue mass from the bone and opening the dorsal synovial roof, the articular surfaces of the joint did not come into view. The metacarpal head was hidden by a ledge of bone projecting dorsally and on its ulnar side. This was leveled off with an osteotome, thus diminishing the anteroposterior and transverse diameters of the metacarpal bone, and reestablishing a normal relationship with the flexor and extensor tendons.

Following closure of the wound, the finger was placed at a right angle with the metacarpal bone. Motion was instituted four days after the operation. Following healing of the wound, physiotherapy was administered.

Six weeks postoperatively there was a normal and complete range of motion with a complete restoration of function of the hand. The head of the metacarpal bone which had been readily palpable in the palm was no longer so after the operation (Fig. 3).

## SUMMARY

The anatomy, pathology, and etiology of knuckle fracture have been presented, with a case of malunion successfully treated by a simple operation. The procedure outlined and carried out on the case presented has the advantage of early motion, attacks the seat of the pathology, does away with the bony prominences, diminishes the anteroposterior and transverse diameters of the metacarpal bone, and reestablishes a more normal relationship with the flexor and extensor tendons. The change in the axis of a malunited knuckle fracture is not corrected by this operation, but this distortion may be more than compensated by the motion normally present in the third, fourth, and fifth carpometacarpal joints.

In malunited knuckle fracture, the space between the extensor tendon and synovial roof may be obliterated by fibrous tissue which limits flexion of the finger and impairs function of the hand. In such a case osteotomy, usually done above the site of the pathology, is of little avail, and may only raise the metacarpal head. Arthroplasty with resection of the normally aligned and intact articular surfaces seems contra-indicated. Certainly, in the author's experience, the ends do not justify the means.

# SESAMOIDS BENEATH ALL THE METATARSAL HEADS OF BOTH FEET

## REPORT OF A CASE

BY PAUL W. LAPIDUS, M.D., F.A.C.S., NEW YORK, N. Y.

*From the Hospital for Ruptured and Crippled\**

The review of roentgenograms of 1,000 feet (by Burman and Lapidus) showed the frequency of inconstant sesamoids given in Table I:

TABLE I

PERCENTAGE OF FREQUENCY OF INCONSTANT SESAMOIDS			
Fifth tibial sesamoid	....	. . .	16 3
Second tibial sesamoid		..	3 4
Fifth fibular sesamoid	..	..	2 9
Fourth tibial sesamoid	.		0 7
Third tibial sesamoid			0 4

A fibular sesamoid was not seen beneath the second, third, and fourth metatarsal heads in this series of feet. Recently, however, the writer has had one case with fourth tibial and fibular sesamoids present in the right foot only (Fig. 1).

The author wishes to record another case (Fig. 2) with six sesamoids: the first tibial and fibular sesamoids, and the second, third, fourth, and fifth tibial sesamoids which were accidentally discovered in both feet of a woman thirty-five years old whom he treated in the clinic of the Hospital for Ruptured and Crippled on June 12, 1929, for a strain of the right foot. Unfortunately no roentgenograms of her hands were taken.

Stieda, Grashey, and recently Patterson each reported a case of multiple sesamoids of the foot. Thilenius proved conclusively the presence of cartilaginous anlage for the two sesamoids beneath each metacarpal head in a number of human embryos at about the third or fourth month. This may just as well be applied to the sesamoids of the feet.

With a few extremely rare exceptions the adult human foot has two constant sesamoids beneath the first metatarsal head. Other foot sesamoids must be considered as inconstant.

The reader is referred to an excellent work of Kassatkin for more detailed study of inconstant sesamoids of the human hand and foot. The latter author examined 770 feet and found, roentgenographically or in cadavera, the second fibular sesamoid in 0.2 per cent. of the feet, and the fourth fibular sesamoid in 0.6 per cent.; the third fibular sesamoid was not present in any of his cases. In only five feet of his series were there sesamoids present beneath each metatarsal head, the largest total being

\*Service of the late Percy W. Roberts, M.D.



FIG. 1

Roentgenogram of feet of a man about forty years old. Tibial and fibular sesamoids (arrows) are present beneath the right fourth metatarsal head. Note also tibial sesamoid beneath the fifth metatarsal heads.



FIG. 2

Roentgenogram of feet of a woman thirty-five years old. Note a sesamoid (arrows) beneath the tibial aspect of each of the lesser metatarsal heads.

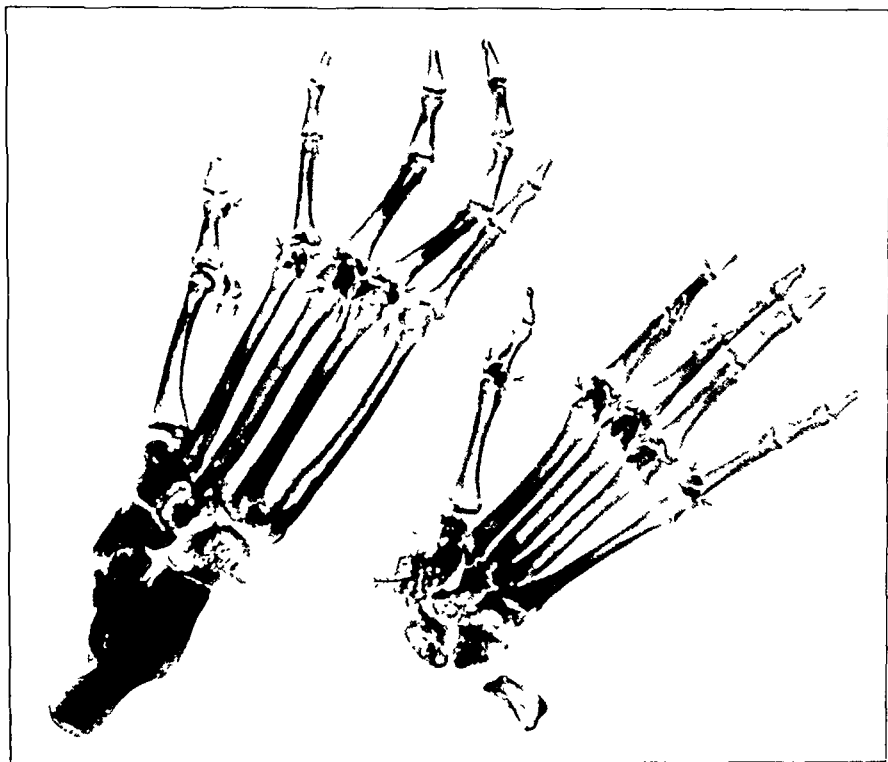


FIG. 3

Roentgenogram of the right foot and hand of a mounted skeleton of an adult baboon. Two sesamoids (arrows) are present beneath each metacarpal and metatarsal head. Note four phalanges of the fourth toe, and also two carpal bones (os naviculare and os centrale, arrow) in place of one human navicular. These two bones are constantly present in the hands of most of the monkeys and may possibly explain the rarely observed congenital division of the carpal navicular in man.

eight sesamoids in one foot: the first tibial and fibular sesamoids; the second and third tibial sesamoids; and the fourth and fifth tibial and fibular sesamoids.

The more frequent occurrence of tibial sesamoids of the second, third, and fourth toes as compared with the extreme rarity of similar fibular sesamoids may possibly be understood if we consider that these sesamoids are located in the tendons of the lumbricales. These muscles run beneath the tibial aspect of the lesser metatarsal heads. The fibular sesamoids apparently fail to develop in human feet. However, this explanation fails to account for the presence of tibial and also fibular sesamoids beneath each metatarsal head in primates which have lumbrical muscles approximately similar to those of the human foot. Possibly the fibular sesamoids of lesser toes in primates are in the tendons of the interossei.

The writer examined, in the New York Museum of Natural History, 320 extremities of various mammals—fifty-six fossils, 192 primates, and seventy-two other mammals—with special reference to the sesamoids.

Two sesamoids were found beneath each metacarpal or metatarsal head (Fig. 3) in almost all adult specimens including fifty-six extremities of fossil animals.

The author wishes to thank Dr. William K. Gregory, Dr. George Pinkley, and Mr. Henry Raven of the Department of Comparative Anatomy of the Museum for their courtesy and assistance during this study.

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# OLLIER'S DYSCHONDROPLASIA

## REPORT OF A CASE\*

BY RALPH M. CARTER, M.D., GREEN BAY, WISCONSIN

Typical, frequently occurring disease conditions have generally been thoroughly studied, and are fairly well understood; it is from the atypical cases that much may occasionally be learned. This is particularly true in the field of bone tumors. The establishment of the Registry of Bone Sarcoma, together with improvements in roentgenography and staining technique, have given a decided impetus to the study of these tumors in recent years. As a result much which was formerly obscure has been cleared up. However, our knowledge is far from complete, and from a study of the literature, it appears that this is especially true with regard to cartilaginous tumors. The case which is reported in this paper represents an unusual example of a relatively infrequent disease, and, as such, is considered of sufficient importance to be placed on record.

On September 19, 1938, E. H., a single man forty-seven years of age, came under observation because of a deformity of his right leg.

Inquiry into the development of the condition revealed that the patient was apparently normal at birth, with both legs symmetrical and of equal length. Sometime during his first year, it was noticed that the right leg was not keeping pace in growth with the left, and was becoming misshapen. With the exception of his right leg, the boy developed normally; the deformity and enlargement of the leg continued to increase slowly until about the age of twenty-one, when the condition became stationary. It had remained so until three or four months previous to the time when he first came under observation. Aside from the inconvenience naturally resulting from the deformity, the leg had given him no trouble whatever. The patient himself had made a brace to overcome the shortening, and had always been active in farm work. No fractures had ever occurred. So far as could be ascertained, no hereditary influence was present, and the previous history otherwise contained nothing of significance.

The patient's chief reason for seeking medical advice was because of severe and intractable pain in the heel, together with a gradual enlargement of the tumor in this region. The pain had begun some three or four months previously and had gradually increased in severity until, at the time he was first seen, it was constant, prevented sleep and rest, and rendered him altogether miserable. The increase in the size of the heel had been gradual, but definite.

Upon examination, the entire right lower extremity was seen to be markedly shortened and deformed, so that in a standing position, the foot of the right leg hung but a short distance below the left knee. The circumference of the thigh was approximately twice that of the normal side, with the enlargement greatest in the region of the hip and knee; a similar enlargement affected the leg below the knee. The foot was a monstrosity, the deformity being particularly marked in the region of the heel, which was greatly swollen, with the overlying skin somewhat discolored and scaly. Upon palpation, the swelling throughout was hard and apparently bony in consistency, except about the heel, where some fluctuation could be detected; and, except in this area, where there was marked tenderness upon pressure, was entirely insensitive. No gross deformities were apparent elsewhere in the body, and the general physical examination was otherwise negative. (See Figure 1.)

\* Presented before the Western Surgical Association, Los Angeles, California, on December 15, 1939.

*X-Ray Findings:*

A roentgenographic study of the entire skeletal system was made. The films of the head, upper extremities, spine, and lungs revealed no abnormalities whatever; those of the lower extremity disclosed a most interesting and unusual condition.

The entire right half of the pelvis, particularly the outer half of the ilium, showed a diffuse mottling, apparently the result of abnormal calcium deposition, although some osteoporosis was also present, especially about the rim of the iliac crest. No cystic areas were visible. This condition extended into the acetabular region, and involved the right pubis and ischium, which were somewhat thickened and deformed. The left half of the pelvis was entirely free from change, as were also the sacrum and lower lumbar spine (Fig. 2).

The upper end of the femur was the site of a bulbous enlargement, with deformity of the neck and trochanteric region; here again the mottling was visible. The shaft of the femur was very short, and the general shape of the bone, with another enlargement at the lower end, was that of a dumbbell. Neither in the pelvis nor in the upper end of the femur did the disease process appear to extend into the surrounding tissues. There was apparently no abnormal periosteal reaction in this region.

The lower end of the femur showed a dense rounded mass, in which very little structure was visible. The actual shaft of the femur appeared to be about two inches in length, with the remainder of the bone consisting of the bulbous enlargements above and below. In the lower end of the femur, the process had apparently broken through the cortex, and numerous strands of calcification were to be seen extending out into the surrounding tissues, giving rise to a definite "sun-ray" appearance. The patella was markedly atrophic, but was apparently not involved in the growth. The space of the knee joint was obliterated (Fig. 3).

The same bulbous enlargement was seen involving the upper end of the tibia. Here again there was no definite periosteal reaction, and no calcification or other signs of extension into the surrounding tissues. The fibula did not appear to be involved.

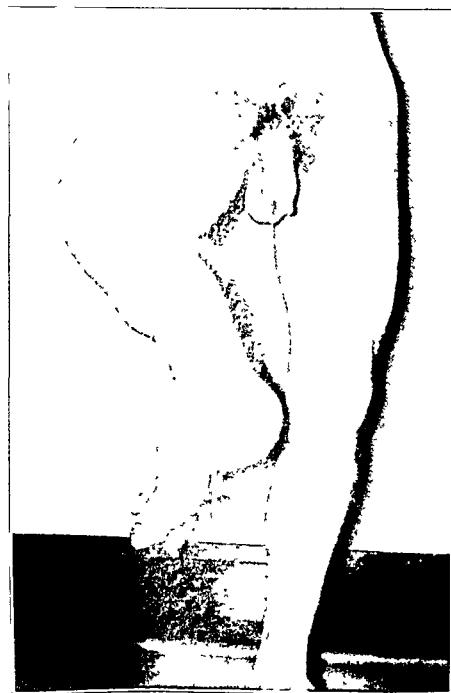


FIG. 1

Deformity of entire lower extremity.

The lower end of the tibia and the foot showed a similar appearance. The posterior portion of the calcaneum appeared cystic, and again the disease process apparently extended into the surrounding tissues, as evidenced by linear calcifications. All the bones of the foot appeared to be involved, with the exception of the fifth metatarsal, but the process was confined entirely to the individual bones, with no breaking of the periosteum, and no soft-tissue involvement (Fig. 4).

Following this examination, a biopsy was requested, but refused. It was recognized that the apparent tumor masses were probably cartilaginous in nature, and were possibly undergoing malignant changes in certain areas. The only treatment recommended was a course of x-ray therapy, in the hope that the pain might thereby be relieved. This was given, with no effect whatever on the pain, and no apparent effect on the tumor tissue.

The patient was lost sight of until January, 1939, four months after he was first seen. During the interval, the pain had become increasingly severe, and he was insis-



tent that something be done. Although it was recognized that it might prove only palliative, especially in view of the wide distribution of the tumor masses in the pelvis, amputation of the extremity was advised, and on January 25, 1939, a disarticulation at the hip joint was performed. He made an uneventful recovery, and at the present time (May 15, 1940), is in excellent health, so far as can be determined by physical examination. A recent roentgenogram shows no apparent change in the disease process in the pelvis (Fig. 5).

*Pathological Examination:*

The pathological examination of the extremity was made by Dr. H. Heitzman, Pathologist for the Bellin Memorial Hospital in Green Bay, to whom the author is indebted for the following report:

"The specimen consisted of an entire right lower extremity 58 centimeters in length. Longitudinal section of the femur [Fig. 6] revealed a definite compact bone cortex 0.2 centimeters in thickness in the proximal half. The spongy bone was firm with scattered areas of pale blue hyaline cartilage, 0.2 to 1.0 centimeters in diameter. The marrow was red. The distal femur revealed the periosteum greatly expanded by a large soft cartilaginous mass which extended to the knee joint with irregular thin plates of bone scattered throughout. Compact bone was present near the anterior surface, with the largest amount of soft cartilage projecting posteriorly. Fibrous septa radiated into the cartilage.

"The sectioned patella showed spongy bone, fatty marrow, and numerous hyaline cartilage masses 0.2 to 0.5 centimeters in diameter.

"The dumbbell-shaped tibia revealed a definite compact bone cortex throughout the shaft. Section revealed areas at both ends of the shaft with firm spongy bone, fatty marrow, and no cartilage. Immediately adjacent to these areas were two others, ap-



FIG. 2

Roentgenogram of pelvis and upper end of femur, showing involvement by tumor

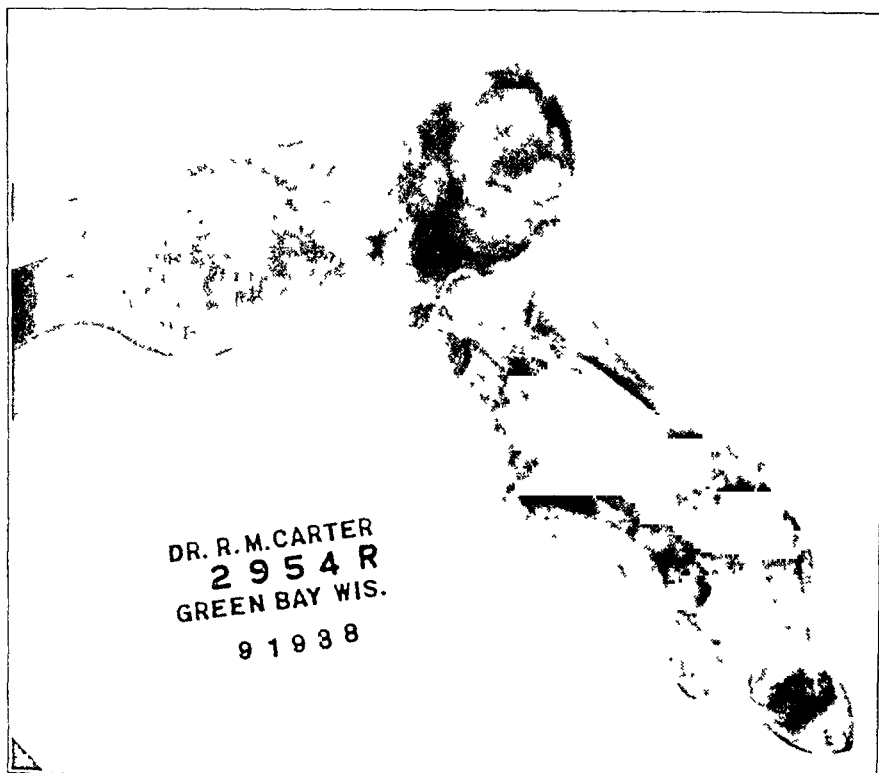


FIG. 4  
Roentgenogram of lower end of tibia and foot.



FIG. 3  
Roentgenogram of lower end of femur, knee joint, and upper end of tibia.

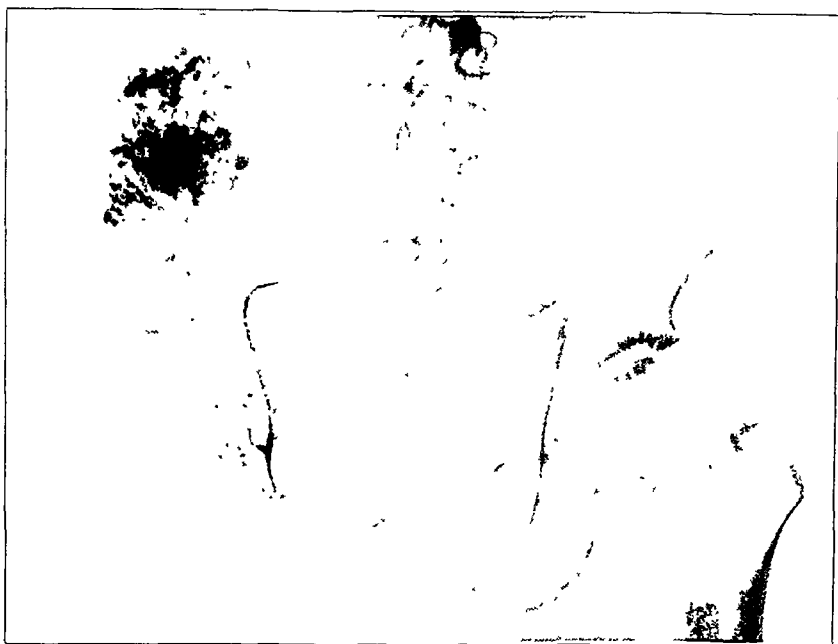


FIG. 5  
Roentgenogram of pelvis after operation.

proximately 6 centimeters in length, which showed numerous hyaline cartilage masses, thin plates of spongy bone, and dense nodules of compact bone. The midshaft revealed no cartilage, and only slight, or no abnormality in the compact or spongy bone.

"The fibula was slightly shorter than the tibia with no external abnormality except slightly enlarged ends. Section revealed small hyaline cartilage masses in the spongy bone of the enlarged ends.

"The entire calcaneum for the most part consisted of a spherical mass of soft cartilage containing small irregular plates of bone. The periosteum could be easily followed about the entire mass, and separated easily from the subcutaneous tissue. No extension through the periosteum was present. Section revealed a flat, opaque gray surface composed of soft cartilage, with a small amount of dark brown blood in the center.

"The other bones of the ankle and foot revealed similar changes, with the relative amount of cartilage showing some variation. Throughout, the muscles were the seat of atrophy, fibrosis, and fat infiltration. The veins were thin-walled, with no invasion by tumor.

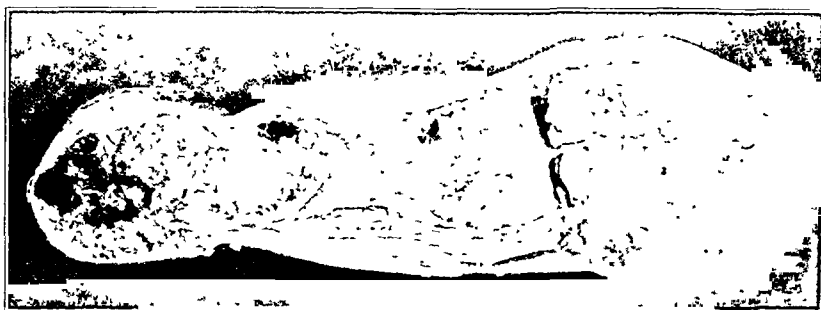


FIG. 6  
Sectional view of gross specimen.

"Upon histological examination, all sections from the distal femur and the calcaneum were similar. The periosteum was intact at the periphery, with immature cartilage the most abundant substance. The intercellular substance varied from coarsely granular to a homogeneous material. There was much variation in the size of the pleomorphic cells, many of which had numerous long processes. Cytoplasm was abundant, vacuolated, and frequently contained large, acidophilic hyaline masses. The nuclei were large, oval, irregular, vesicular and eccentric. Binucleate cells were frequent. A large, single basophilic nucleolus was present. Mitotic figures were not seen.

"Small plates of bone occurred throughout the immature cartilage. Osteoblasts varied in number. Few osteoclasts were present. Thin-walled blood vessels occurred. No invasion of the blood vessels was seen.

"Sections from the proximal tibia revealed a more mature type of hyaline cartilage, with small irregular foci of bone platelets."

#### DISCUSSION

There remain to be briefly discussed, first, the diagnosis, and second, of particular interest and importance in this case, the prognosis. Taking into consideration the onset in early life, the apparent original localization of the cartilaginous masses in the epiphyseal regions of the long bones, the benign course, and the histological appearance of the tissue, the condition appears to be one of Ollier's dyschondroplasia. Dr. D. B. Phemister, of Chicago, who reviewed the roentgenograms and sections of the tissue, concurred in this diagnosis.

The disease is one affecting bone formed in cartilage, and was described in 1899 by Ollier as dyschondroplasia. At the epiphyseal line, the cartilage proliferates normally, but normal degeneration and calcification, and therefore, ossification are prevented. In consequence, as the bone grows in length, there persist in the diaphysis masses of unossified cartilage. Apparently, as in this case, these masses of cartilage may occasionally take on independent growth, until huge tumors are formed. Also occasionally, according to Hunter and Wiles, sarcomatous change may supervene.

Assuming Ollier's conception of the disease to be correct, it seems apparent that it is not a true neoplasm in the strict sense of the word; but rather is the result of disturbance of the physiological processes of bone growth and development, due to undetermined factors. These disturbances may exist in localized areas, side by side with normal bone development; as a result of this, deformities are produced. In other words, if this theory is true, the deformities result from a retardation of growth of certain portions of a bone, with normal growth in other portions of the same bone. Under these circumstances, the deformities present in the majority of cases of Ollier's dyschondroplasia rarely attain the extreme degree seen in the case which has just been described.

In this case, to produce the gross malformation which the patient presented, the cartilaginous "rests", if they may be so called, must have taken on independent growth, and this, too, greatly at the expense of the normal bone-producing portions. This is particularly true at the upper and lower ends of the femur, upper end of the tibia, and the calcaneum.

In these regions, at least, the tumors appear to approach very closely the character of true neoplasms, or enchondromata.

Finally, in this particular case, there has to be considered the question of malignancy. From the roentgenograms of the lower end of the femur and of the calcaneum, it seems apparent that the growth has broken through the cortex of the bone, and is invading the surrounding tissues. This, in itself, suggests that the tumors are not benign, at least in these particular regions. However, this roentgenographic appearance is not borne out by actual examination of the tissues. As was stated in the pathological report above, the periosteum everywhere appeared to be intact. The history of renewed growth after a long period of quiescence in the region of the heel is also significant. On the other hand, from the histological examination of the tumor tissue, no definite conclusions can be drawn; likewise no invasion of the blood vessels can be demonstrated.

In this connection, Phemister writes as follows:

"... The interesting feature to me is the cartilaginous overgrowth about the periphery of the central expansile mass at the end of the shaft of the lower part of the femur and os calcis. Considered separately, these lesions look like chondrosarcomatous developments in the x-ray and histologically the tissue is compatible with chondrosarcoma. However, growing, benign cartilaginous tumor and chondrosarcoma are very difficult to differentiate microscopically. Consequently I wouldn't want to say that malignancy had set in here unless the patient subsequently develops a metastasis."

Heitzman of the Bellin Hospital was likewise unable to express a definite opinion as to the presence or absence of malignancy, and apparently the question can only be decided by the future course and outcome of the disease.

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# REPAIR OF OLD RUPTURE OF THE TENDO ACHILLIS BY MEANS OF FASCIA LATA

## REPORT OF A CASE

BY ISADORE ZADEK, M.D., NEW YORK, N. Y.

Complete rupture of the tendo achillis is a rare lesion. It is surprising that it does not occur more frequently. Partial rupture of the tendo achillis is not so rare, and partial rupture of the calf muscle, usually considered as a rupture of the plantaris, is relatively common.

H. G. G., aged thirty-seven, was first seen by the author on September 8, 1937, complaining of trouble with his left leg. He was a director of activities for boys, and had been accustomed to doing acrobatic stunts for many years. One month before he was seen, he was doing a stunt which he had done for many years called a "balking mule", in which he snapped his body forward and backward with his hands in contact with the floor. On this particular occasion, the patient experienced sudden pain in the region of the left heel cord, and felt as though he had been struck with a baseball bat. He had to stop stunting at once. On the day of the accident, he had a great deal of discoloration about the ankle. He gradually began to walk with the affected extremity in outward rotation. The accident occurred during vacation, and two weeks later the patient drove his car 1000 miles. When driving, he pushed in the clutch pedal with his heel, and when walking, he used two canes. He was unable to place his left foot firmly on the ground and could not flex it.

When he first consulted a doctor, two weeks after the injury, he was given massage, but failed to improve. The depression in the heel cord, which had previously existed, had grown deeper, and he had lost power in his calf muscle. He felt able to walk only upon his heel. He was forced to use crutches for the first time on the day he was seen by the author.

*Examination:* His general condition was good. He walked with crutches and had a marked limp on the left side. There was a wavy depression three-fourths of an inch wide in the course of the tendo achillis, beginning two inches above the upper border of the os calcis. He was not sensitive at the site of rupture. He had completely lost the power of plantar flexion of the left foot. The calf showed only slight atrophy. His foot was otherwise negative and circulation in the foot was good.

*Diagnosis:* A diagnosis of old rupture of the left tendo achillis was made, and operative repair with fascia lata was advised.

*Operation:* The patient was operated upon on September 9, 1937, at the Mount Vernon Hospital. The tendo achillis was exposed through a six-inch incision, and was found completely torn. The lower end of the upper portion was conical in shape, and the upper end of the distal fragment was bulbous and redundant. There was no tendinous tissue inside the sheath at the site of the defect. In other words, the rupture was complete. The gap, an inch and a half wide, was larger than it had seemed clinically. After the two ends of the torn tendon had been freshened by cutting away the abnormal portions, there was a gap of about three inches, with the upper portion of the defect at the musculotendinous junction. No separate sheath could be identified.

Three strips of fascia lata, one-half inch wide and six inches long, were taken from the left thigh. The upper portion of the tendon was split in a sagittal plane and the lower portion in a coronal plane. The strips of fascia lata were woven into the split portions of the tendon, sewed to each other, and sutured under slight tension with heavy chromic gut. The other deep soft tissues were closed with chromic gut, the subcutaneous tissue with

plain catgut, and the skin with silk. With the foot in slight equinus a plaster-of-Paris cast was applied extending from the toes to the knee.

On September 20, 1937, the plaster-of-Paris cast was removed, and a new walking cast was applied, extending from the toes up to the knee with the foot at a right angle. At this time he showed fair power in the calf muscle.

On September 23, 1937, he was discharged from the hospital, walking with crutches and bearing his weight. His further course was uneventful. Five weeks after the operation, he was fitted with an ankle brace with attached foot piece, allowing limited motion, which he used for five months.

Patient was last seen by the author two years after the operation. He stated that he could do his usual athletic stunts as well as he had

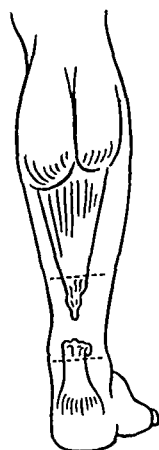


FIG. 1-A

Showing the tendo achillis as found at operation.

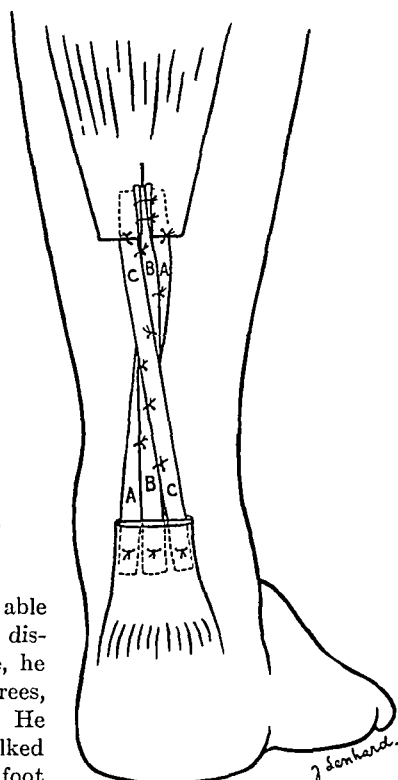


FIG. 1-B

Method of repair by the use of strips of fascia lata.

prior to the injury, and he had no pain. He was able to play eighteen holes of golf without strain or discomfort, run, and play basketball. At this time, he had motion in the left ankle from 80 to 130 degrees, compared with 80 to 135 degrees in the right. He showed excellent power in the left calf muscle; walked without limp; and could rise on the toes of his left foot and bear his weight without difficulty. There was no local sensitiveness. He demonstrated the "balking mule".



FIG. 2

Two years after operation. Patient standing on a stool, and bearing weight on the left forefoot. The outline of the reconstructed tendon is clearly evident.

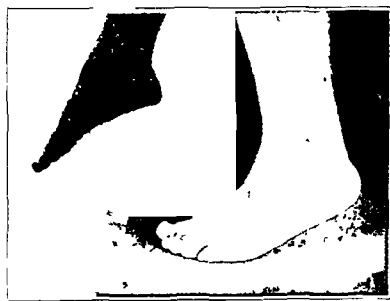


FIG. 3

Two years after operation. Patient bearing weight on the left forefoot as seen from the side.

# A SIMPLE METHOD OF REDUCTION AND FIXATION OF COMPRESSION FRACTURES OF THE SPINE

BY EDWARD PARNALL, M.D., MINOT, NORTH DAKOTA

*From the Department of Bone and Joint Surgery, Northwest Clinic, Minot*

Within the last dozen or fifteen years the hyperextension mechanism for treating compression fractures of the vertebrae has been evolved and variously elaborated. The most profound comments on this mechanism were made by Davis.<sup>1</sup>

For the maintenance of tension, a satisfactory body cast, holding the spine in hyperextension, is a prime requisite. Probably one of the most efficient ways of getting proper hyperextension would be to arch the patient's trunk backward over a barrel. But alas, a barrel can be neither comfortably incorporated in a cast nor conveniently slid out of it. Application of a cast with the patient supine on a canvas hammock can only be condemned, since in using it one can achieve neither the sharp degree of hyperextension necessary, nor fit the plaster comfortably around the pubes and clavicles. Some methods seem rather precarious (Watson-Jones), and others require apparatus that entails quite an expense (Rogers frame). The original—and probably the most efficient—method of Davis<sup>1</sup>, suspension by the heels in supine position, is simple, but uncomfortable for a conscious patient, and difficult for the surgeon when he applies a cast instead of anteroposterior shells.

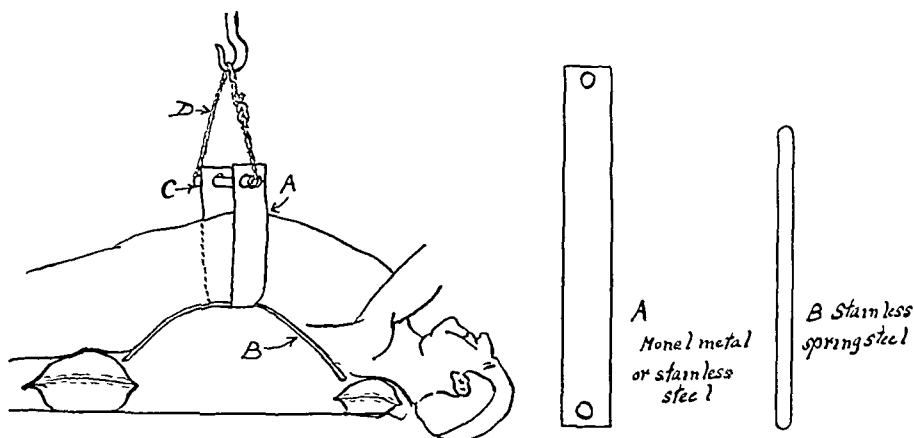


FIG. 1

The author has found the following method simple and inexpensive, with a fulcrum of curvature that can be accurately adjusted to whatever lumbar or thoracic vertebra is involved.

The apparatus (Fig. 1) consists of a block and tackle, suspended from an adequate overhead fixation point; a thin band (A), about forty or forty-five inches by three and one-half inches; two strips of spring



steel (*B*), about one inch wide and thirty inches long; a cross bar (*C*) of ordinary one-inch pipe; and a length of stout rope or sash cord (*D*). Holes, to receive the ends of the cross bar, are drilled in each end of the band, which is made of monel metal, stainless steel, or other non-malleable metal which retains its smooth surface.

The patient is placed in a supine position, upon adequate felt padding, with the two spring-steel strips, which have been coated with a thin film of mineral oil, placed underneath, one on each side of the spinal column. The wide metal band is then slid across, underneath the whole, at the level of the compressed vertebra, and the ends brought up on either side. The ends of the pipe cross bar, with the sash cord threaded through it, are put through the holes in the band, the cord made fast, and the patient pulled up with the block and tackle until he swings clear of the table. Sand bags may then be put under the shoulders and buttocks to steady him. While the patient is well hyperextended across the suspension band, the two longitudinal strips prevent too exaggerated a degree of angulation, and make the curve smooth and comfortable. A long body cast reaching from the symphysis pubis to the sternal notch is applied in the usual manner. When the cast is set, the strips are easily slipped out.

The duration of recumbency following application of the cast is a matter of judgment, and may be anywhere from one to six weeks. In general, a tall, heavy man with a long trunk will require a longer time than a short, light person, since the apophyses of the former cannot be depended upon so confidently to sustain the weight without some collapse of the vertebral body. Lateral roentgenograms are the most reliable check on the condition from time to time. A properly placed window on each side permits the observance of bone detail, and in no way spoils the efficiency of the cast. The writer does not employ any steel back brace, since the best of them does not really immobilize a spine. This apparatus, however, makes it quite easy to change casts as often as desired, so that immobilization may be continued for six months or longer if necessary.

While this method offers no radical departure from the principles laid down by Davis, and the results attained by its use in no way differ from the usual end results of *proper* hyperextension and immobilization, the apparatus can be used for nearly all compression fractures, with or without cord involvement. Its chief advantage is security at all stages of operation, with delicacy and accuracy of adjustment.



FIG. 2

Two weeks after reduction and application of cast. Note that cast reaches from sternal notch to the symphysis pubis, and fits snugly under the axillae.

An important contra-indication to its use, however, is any fracture of a posterior arch at the point of fulcrum desired, which may be further injured by such stress. In such cases the Davis or Watson-Jones method is the one of choice.

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# TUBERCULOSIS OF THE GREATER TROCHANTER AND TROCHANTERIC BURSAE

BY JOSEPH D. WASSERSUG, M.D., MIDDLEBORO, MASSACHUSETTS

*From Lakeville State Sanatorium, Middleboro, Massachusetts*

Tuberculosis involving the greater trochanter or the trochanteric bursae is still regarded as rare although more than seventy-five cases have been reported in the literature. Of 1,017 cases of bone and joint tuberculosis admitted by the Lakeville State Sanatorium, during the twelve-year period from 1928 to 1939, eighteen cases of trochanteric disease were found, an incidence of 1.8 per cent. Peabody<sup>10</sup> found that in the Massachusetts General Hospital from 1870 to 1920 the diagnosis of tuberculosis of the trochanter was made just five times.

In this series of eighteen cases, five had disease only in the trochanter; no other focus could be found. In two cases, the bursae alone were involved, and there was no evidence of a trochanteric bone lesion.

Tuberculosis of the trochanter occurs most commonly in young adults. Perrin<sup>11</sup> described a case in which the trochanter was involved in a boy three and one-half years old, the youngest of any of the reported cases. The average age of onset of symptoms in the present group of cases was twenty-five and one-half years, with the ages varying from seven to fifty-five years.

A greater number of cases occurred in males than in females. There were thirteen males and five females.

The left side was involved in thirteen cases, and the right in only five. This differs from the observations of Meyerding and Mroz<sup>9</sup> who found disease on the right side in fourteen out of nineteen cases. Apparently the disease occurs with about the same frequency on either side.

Of the eighteen cases studied, a history of local trauma was obtained in nine. In two additional cases, trauma resulted in an exacerbation of arrested lesions. The interval between traumatization and onset of symptoms varied from two months to fifteen years, with an average period of six and one-quarter years. This is essentially in agreement with the figures cited in the literature.

The presence of a demonstrable tuberculous focus is a second etiological factor. Only five of the eighteen cases had no demonstrable lesion other than the trochanteric disease. In thirteen, or 72 per cent., other tuberculous lesions were found. Of these thirteen, a history of trauma was obtained in six. Of the five cases in which no tuberculous focus could be demonstrated, three gave a definite history of local injury.

## DIAGNOSIS

The diagnosis of tuberculous trochanteritis is not simple. It is frequently mistaken for other conditions about the hip, and has been con-

fused with osteochondritis deformans <sup>1</sup>, lipoma <sup>3</sup>, tuberculosis of the hip <sup>5</sup>, Pott's disease <sup>4</sup>, neoplasms of the femur <sup>7, 10</sup>, and hematoma <sup>8</sup>.

Pain in the region of the hip is the most common symptom, and it was the presenting symptom in fourteen of the eighteen cases. In the remaining four cases, the initial complaint was the appearance of a lump or abscess in the vicinity of the trochanter. The development of a sinus is common, but the diagnosis can usually be made before this complication occurs. Eleven of the fourteen patients who complained first of pain subsequently developed a swelling over the trochanter. The pain experienced is usually intermittent, but may later become continuous; it is relieved by rest, and aggravated by walking, exercise, and change of posture. In two cases, damp weather aggravated the pain in the hip.

Examination may yield but little information and, in the presence of characteristic symptoms, the absence of positive signs of hip disease is strongly suggestive of trochanteric involvement. The patient does not lie or stand in any characteristic attitude, but he may limp slightly. There is never any shortening, and atrophy of the thigh muscles is unusual. There may be some local swelling, but, until an abscess is about ready to discharge, there is no local heat or redness. Local tenderness, however, is a very common finding, and the tenderness is usually directly over the trochanter. Generally, movements at the hip are not restricted or painful. Even with extensive swelling in the region of the thigh, hip motion is fairly free.

In the majority of cases, roentgenograms are indispensable. In some cases, however, when x-ray examination is done early in the disease, or when the bursae alone are involved, the roentgenogram may be of no help. In a few other cases roentgenographic study may be definitely misleading. Differentiation between tuberculosis of the trochanter and neoplasms of the femur is sometimes exceedingly difficult. In this series of cases, roentgenograms revealed bone destruction in every case where the trochanter was involved. Occasionally, in obscure cases, the injection of a radio-opaque substance into a sinus leads to a correct diagnosis.

The diagnosis of tuberculous disease should be confirmed by bacteriological or histological methods or both. Guinea-pig tests should be made on all fluid obtained by aspiration, and on material draining from sinuses. Rarely, guinea-pig tests on fluid obtained in this way may be negative, and yet material from the abscess wall may be characteristically tuberculous. Sixteen of our cases were operated upon, and the diagnosis was confirmed in fifteen. In the remaining case, smear and culture of aspirated fluid were negative, but the diagnosis was later confirmed at autopsy.

Of the fifteen cases confirmed at operation, ten were confirmed histologically, two bacteriologically, and three by both methods. The two cases which were not operated upon had extensive bone and joint. pulmonary, or urogenital tuberculosis, and the diagnosis was made on roentgenographic evidence.

In all cases, the tuberculin test was positive, and the blood Hinton negative. In no case was there a history of tuberculosis in the family or a history of contact.

#### TREATMENT

There is unanimity of opinion that surgical intervention is preferable to conservative treatment. Chakir <sup>2</sup> and Herlyn <sup>6</sup> believed that operation shortened the duration of the illness, and that delay led to the development of fistulae. Meyerding and Mroz <sup>9</sup> felt that the treatment should be radical excision as soon as the diagnosis is made. This viewpoint is corroborated by our study.

The eighteen patients in our series had a total of forty-three operative procedures performed for their trochanteric disease. These were three aspirations, four sequestrectomies, six curettements, seven biopsies, eight excisions or resections, and fifteen incisions for drainage. Two patients were not operated upon at all; one was operated upon five times. Incision and drainage were done as a palliative measure for two patients too poor a risk for further surgery, both of whom died. In a third case, incision and drainage, but no other operation, were done on three different occasions, and the drainage from sinuses has persisted for more than twenty-five years. Incision was done only once in eight other cases and in seven of them further operation was required. The eighth patient still has a discharging sinus three years after his original incision and drainage. Thus, incision and drainage, which are so commonly done, appear to be without any permanent benefit.

Radical excision, resection, or thorough curettage gives superior results. Such operations were performed in ten cases, and in no case was there drainage or sinus at the time of the patient's discharge from the hospital. Six of these patients were followed for an average period of four years after leaving the Sanatorium, and none of them had any recurrence of swelling, drainage, sinus formation, or spread of the disease.

In most cases, plaster immobilization of the hip is unnecessary. When there is no evidence of hip-joint involvement, little is to be gained by the use of plaster. On the other hand, post-operative cases sometimes benefit from a plaster cast, because of the protection it affords. There were two cases in the series that were not operated upon, and the only treatment given was immobilization in plaster. Both had serious tuberculosis in other organs of the body. One was in plaster for six months; the other, for one year. In both cases, the end results were satisfactory.

#### END RESULTS

Tuberculosis of the trochanter must be regarded as a serious and disabling illness because of its chronicity and the necessity for prolonged or repeated hospitalization. Of the eighteen patients in this study, four are at present still hospitalized. The remaining fourteen patients stayed at the Sanatorium a total of twenty-one and one-quarter years, or an

average of one and one-half years. The shortest stay was six months; the longest almost six years. Of the fourteen discharged patients, four have died. Eight of the remaining ten have been followed periodically for a total of twenty-three and one-half years, or an average of three years each. Even the five patients who had no tuberculous disease other than the trochanteric involvement remained in the hospital an average of thirteen months. Each of these patients has been followed for an average of four years since leaving the Sanatorium. Except for one of them who became insane and died, all are in good health, and have practically no complaints referable to the trochanter. The patients with the trochanteric bursitis are also free from symptoms.

The prognosis in uncomplicated trochanteric disease is good. The disease has no mortality *per se*. Two patients, who had extensive and multiple tuberculous foci, died while in the hospital. A third death occurred in a sixty-year-old man, six months after transfer to a hospital for the insane. The fourth patient, a man sixty-eight years old, died of cerebral hemorrhage, eleven months after discharge.

#### ILLUSTRATIVE CASE

W. F., a forty-one year old male, first complained of pain in the left hip in January 1930. The pain was worse at night, and was aggravated by getting up from a seated position. About two months previously, he had received a blow on his left side. He walked with a limp, and a fluctuant mass was felt over the left trochanter. Motion of the hip was somewhat restricted. Roentgenograms showed almost complete destruction of the left greater trochanter, and numerous dense fragments of bone in the soft tissues. After one week of bed rest, the patient was able to get about without pain, and refused operation. He remained relatively symptom-free for three years.

In February 1933, patient again complained of severe pain, and the presence of a mass in the left upper thigh. Examination revealed slight atrophy of the thigh and the presence of a cystic bilobular abscess in the upper thigh region. This abscess of the

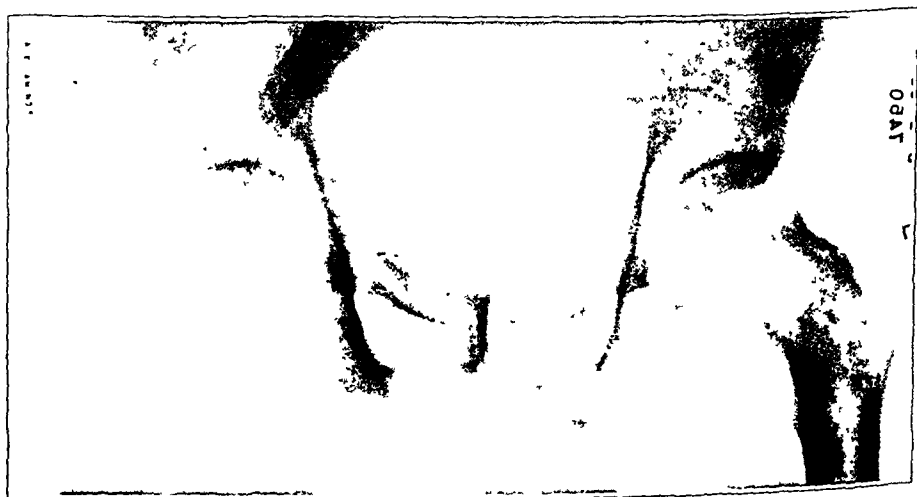


FIG. 1.

W. F. Roentgenogram taken six months after operation. Note complete absence of left greater trochanter. Excellent functional result was reported six and one-half years later.

left greater trochanter was incised, drained, and thoroughly curetted. Pathological diagnosis was tuberculosis. Postoperatively, patient was given a Thomas splint, and was transferred to the Lakeville State Sanatorium.

On admission, March 3, 1933, he had a healed scar on his left thigh. All movements of hip were free, non-painful, and non-restricted. Roentgenogram showed left greater trochanter surgically removed, and several rarified areas in the neck of the femur, adjacent to the greater trochanteric region. Patient was given a short single plaster spica, because it was felt that there might be extension of the disease into the femoral neck. Three months later, he was allowed out of bed, and his improvement continued until September 17, 1933, when he was discharged (Fig. 1).

In February 1940, six and one-half years after discharge, patient had no pain, swelling, lameness, or sinus formation; movements at hip were not restricted. He had been steadily employed as a mattress-maker.

#### SUMMARY AND CONCLUSIONS

1. Eighteen cases of tuberculosis of the greater trochanter and the trochanteric bursae are analyzed.

2. Fifty per cent. of these cases had a history of local trauma; in 72 per cent. there were one or more other demonstrable tuberculous foci.

3. The diagnosis of trochanteric tuberculosis is frequently missed because there is no characteristic clinical or roentgenographic picture.

4. Radical surgical treatment is preferable to prolonged conservative measures.

5. Tuberculosis near the hip joint is serious because of its chronicity and the necessity for prolonged hospitalization.

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# ASEPTIC NECROSIS OF BONE OCCURRING IN CAISSON DISEASE

## A CASE REPORT

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*From the Orthopaedic Service,\* Bellevue Hospital*

The subject of aseptic necrosis of bone occurring in caisson disease was reviewed by Kahlstrom, Burton, and Phemister<sup>1</sup> a year ago, and four cases were reported by them. They were the first to give the pathological findings in the late bone changes in this condition. This they did by autopsy in one case and biopsy in another. They concluded that, in caisson disease, nitrogen-bubble emboli in the blood stream caused infarction with subsequent aseptic necrosis of intramedullary bone. Since fat absorbs five times as much nitrogen as blood plasma, long bones were involved because of the higher fat content of the yellow bone marrow. The cortex was spared because of its richer blood supply.

Later changes in the process following necrosis were reparative in nature. Within the shafts of long bones the necrotic area was surrounded by a fibrous wall which went on to calcification and ossification. At the same time there was some replacement of dead bone by invasion of new bone. These processes went on until the strength of the bone had reached normal. When a weight-bearing epiphysis, such as the head of the femur, was involved, there was early collapse followed by repair by means of new bone invasion and replacement, and calcification of non-substituted portions. Sections through the diaphyses revealed areas of grayish and brownish debris surrounded by an encapsulating wall of calcified fibrous material, while those through the head showed bone with areas of varying density but no areas of debris.

The case here reported is in all respects similar to those reported by these other named authors.

E. M., a white male, fifty-five years of age, Finnish by birth, and a carpenter by occupation, was admitted to the Orthopaedic Service at Bellevue Hospital on September 2, 1939. His chief complaint was pain and stiffness of the right hip of twenty-five years' duration.

The patient had gonorrhea thirty years ago; denied having had lues; and never had rheumatic fever. He fractured his right leg and hip twenty-three years ago; and was thought to have had appendicitis sixteen years ago, but he believes that the pain was from his hip. The family history was irrelevant.

Twenty-six years ago the patient was employed on the construction of a pier of the Hell Gate bridge, working under air pressure of fifty pounds. He developed a typical case of caisson disease after being decompressed for the short period of five minutes. He was not recompressed. Symptoms were cramp-like pains in the abdomen and legs, nausea and vomiting, and bleeding from the ears and mouth. These disappeared after three weeks. He did not return to work under increased pressure. One year later he first noticed stiffness and pain in the right hip. This disability persisted and increased to such an extent that he had been unable to put on his right shoe for ten years. However, he was able to, and did continue his work as a carpenter until his admission to

\* Service of Arthur Krida, M.D.



Bellevue, August 11, 1939. On that date he was struck by an auto and sustained contusions of the entire right side of the body, and minor fractures of the right foot and right hand. He was treated elsewhere in the Hospital for these injuries, and for acute alcoholism prior to his transfer to the Orthopaedic Service for treatment of his "arthritic" hip.

Physical examination showed the patient to be a well-developed and well-nourished man, confined to bed, and unable to walk because of pain in the right hip. Regional examination, except for the hip, was negative. His hearing was unimpaired.

The laboratory findings were as follows:

Urinalysis—specific gravity 1.021, negative  
Red blood cells—5,100,000  
Hemoglobin—90 per cent.  
White blood cells—8,190  
Polymorphonuclear neutrophils—68 per cent.  
Lymphocytes—32 per cent.  
Blood Wassermann—negative  
Sugar—90 milligrams  
Calcium—10.3 milligrams  
Phosphorus—2.0 milligrams  
Phosphatase—7.9 milligrams  
Non-protein nitrogen—33 milligrams  
Urea—21 milligrams

The right hip rested in slight abduction, flexion, and external rotation. There was slight atrophy of the thigh and leg. Motions of the hip were markedly restricted. Flexion of 5 degrees and abduction of 5 degrees were the only motions obtainable. The measurements of the lower extremities were R. U.  $37\frac{1}{2}$  inches; L. U.  $36\frac{1}{2}$  inches; R. A. 33 inches; L. A. 33 inches (apparent lengthening, one inch; actual lengthening, none).

Roentgenograms of the entire skeletal system were made, and are the important factor in the diagnosis of this case. Those of the right hip revealed an irregularly flattened femoral head, throughout which there are numerous areas of decreased density surrounded by bone of increased density, lacking in fine bone detail. There was some irregularity of the acetabulum corresponding to that of the head, and moderate narrowing of the joint space, with marked hypertrophic marginal changes of both the head and acetabulum. The diaphysis of the lower right femur revealed an irregular area, four inches in length, of unevenly increased density, which was quite sharply demarcated distally and faded off proximally. It did not extend within the epiphysis, or involve the cortex. There was a similar shadow of increased density in the diaphysis of the upper right tibia. It, too, was demarcated on its epiphyseal boundary and faded off toward the central part of the shaft. Again there was no involvement of the cortex. There is a well-healed fracture at the level of the lower and middle thirds of the right tibia.

Within the medullae of the proximal phalanges of the right second, third, and fourth fingers there were several tiny areas of irregularly increased density, and also a suggestion of irregular areas of decreased density in the cancellous bone. No other bones were involved. All flat bones were negative.

#### *Operative Procedure*

On October 2, 1939, the right hip was arthrodesed through an anterolateral incision. A Ghormley type of intra-articular fusion, which afforded the removal of a substantial section of the femoral head, was done. The exposed joint showed the characteristic changes found in osteo-arthritis,—thickened capsule, injected synovia, thinned and eroded articular cartilages, and marked hypertrophic marginal changes.

A portion of bone was removed from the front of the right tibia three inches below the knee joint. The cortex and underlying cancellous bone were removed, but no debris was noted, probably because the section was not removed deeply enough.

The patient was placed in a hip spica, and his postoperative course was uneventful, except for a rise in temperature on the thirty-eighth day which persisted for ten days.

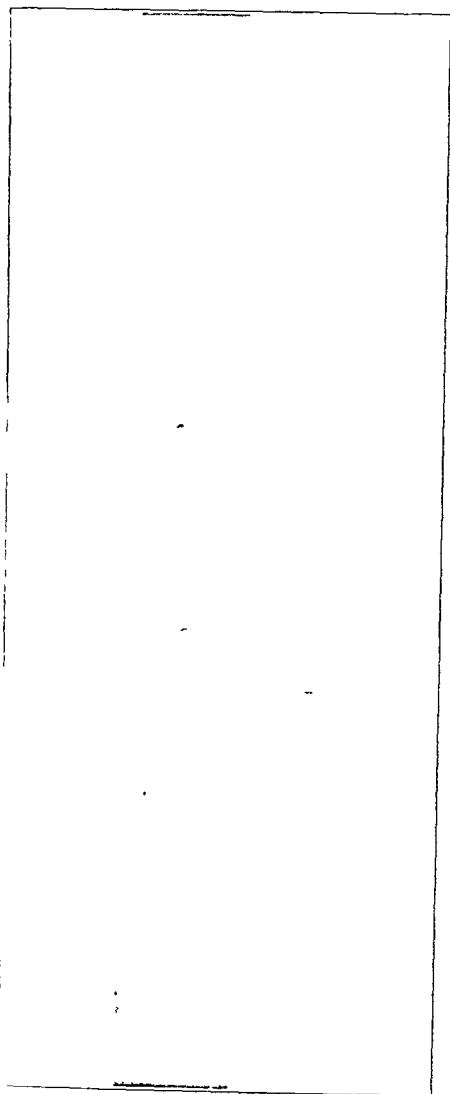


FIG. 1

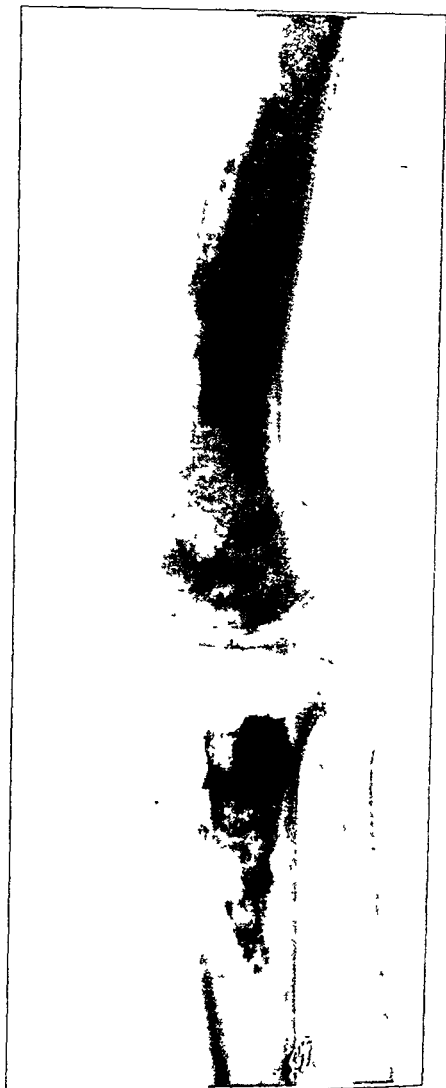


FIG. 2

Fig. 1: Anteroposterior view of right lower femur and upper tibia.

Fig. 2: Lateral view of right lower femur and upper tibia. (Defect in cortex inferior to tibial tubercle is site of biopsy.)

This was ascribed to a pneumonia of unknown type, the plaster making adequate chest examination impossible.

Microscopic examination of bone removed from the femoral head revealed scattered areas of increased density. No areas of debris were found. In the section from the upper tibia the cortex and immediately underlying cancellous bone were normal. Toward the medulla some calcified material was found as well as areas of necrotic bone. No gross debris was found. Figure 5 is a photomicrograph of a section from this biopsy.

There can be no doubt that the lesions of the right femoral head and lower shaft, and right upper tibia are on a nitrogen-embolism basis. The only trauma that the patient sustained was a fractured tibia, and that occurred two years after the onset of symptoms in the hip. The likelihood of fat embolism can hence be ruled out. It is likely that the so-called fractured hip twenty-three years ago was the collapse of the necrotic head mistakenly diagnosed as a fracture.

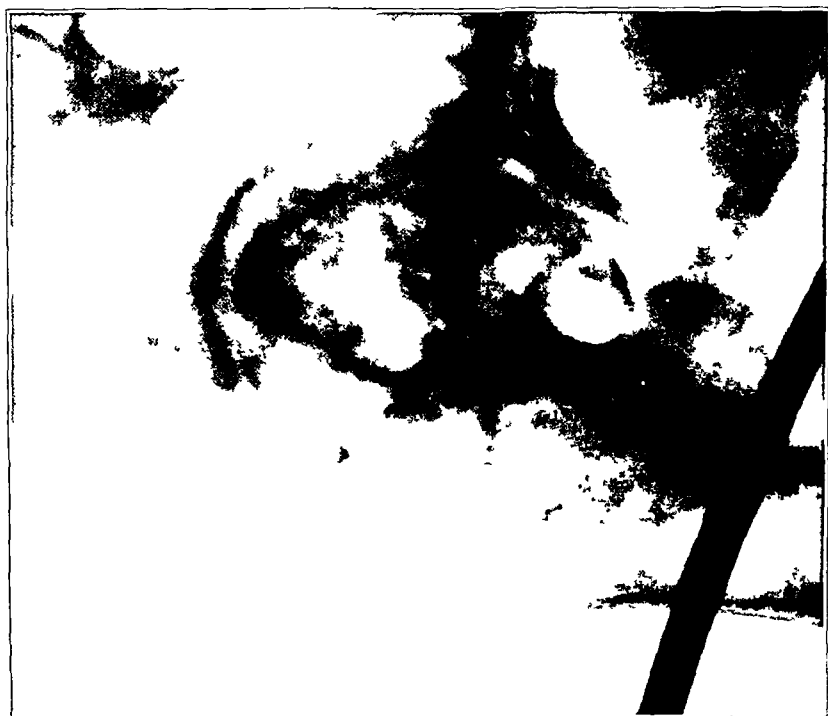


Fig. 3  
Preoperative anteroposterior view of the hip

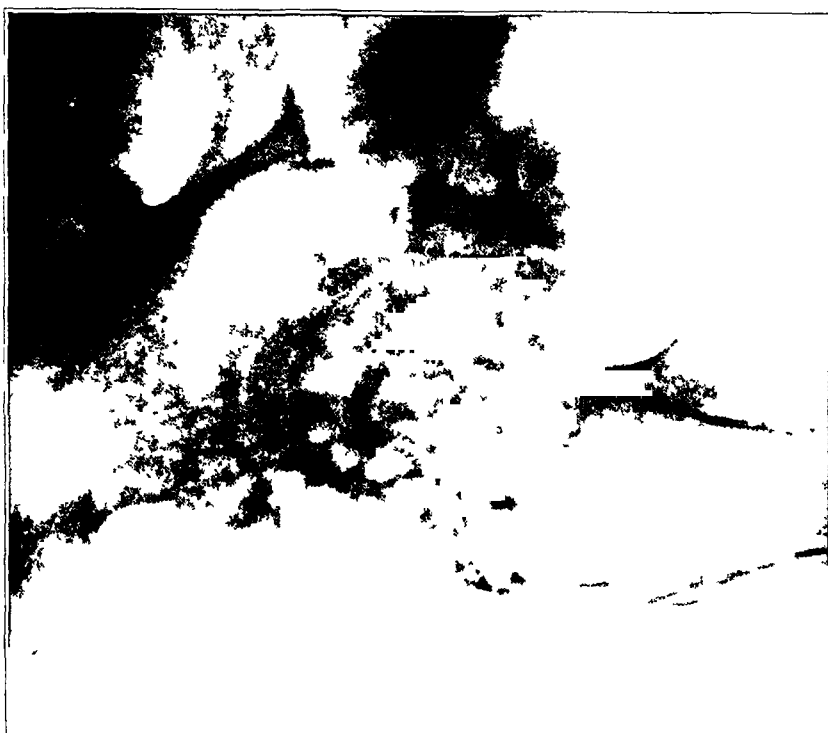


Fig. 4  
Postoperative anteroposterior view of the hip showing bone graft



FIG. 5

Photomicrograph (low power) of biopsy specimen removed from the upper tibial lesion.

At the extreme right there is a necrotic spicule of bone with empty lacunar spaces and walled off by a thin rim of calcium. Scattered fragments of necrotic calcified bone are present throughout, visible as dark-staining masses; also some osteoblastic proliferation which probably walls off the massive infarct.

The character and distribution of the changes noted by the roentgenographic and biopsic findings in this case are practically identical with those of Phemister's cases. The irregular areas of increased density in the lower femur and upper tibia represent the calcified and ossified encapsulating wall surrounding debris of necrotic bone. The femoral head is flattened as a result of weight-bearing while necrotic. Its mottled appearance is due to irregular invasion of new bone and calcification of non-substituted areas.

The author wishes to acknowledge the assistance of Dr. Frank Nobilette, Resident Surgeon at Bellevue Hospital, and of Dr. D. A. DeSanto, Pathologist at the Hospital for Ruptured and Crippled.

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# AN ACTIVE THREE-POINT-PRESSURE SCOLIOSIS BRACE

BY THOMAS HORWITZ, M.D., PHILADELPHIA, PENNSYLVANIA

This brace is suggested for the ambulatory treatment of lateral curvatures of the spine which are primary in the midthoracic, lower thoracic, and thoracolumbar regions, and which are completely or partially flexible. The essential feature of its mechanism is the associated action of the components of an active three-point-pressure unit. This principle has been employed in several previously reported scoliosis braces. It was designed originally by an ingenious bracedman, and, following clinical trial during the past four years, has been modified by the author.

The brace selected for description has been designed for a right

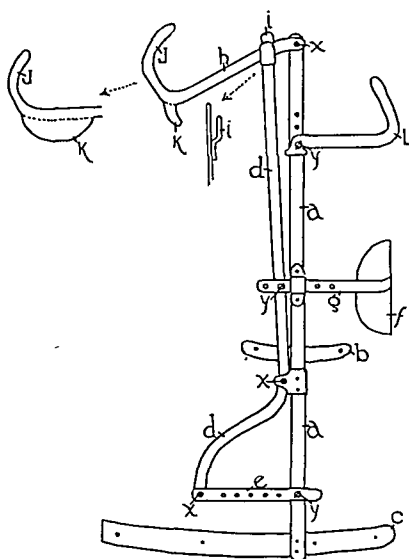


FIG. 1-A

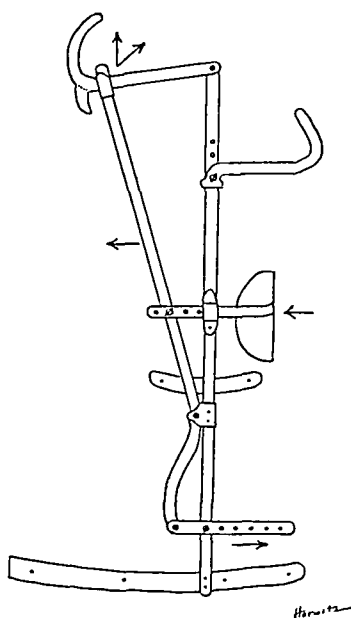


FIG. 1-B

Diagrammatic representation of the brace before (Fig. 1-A), and after (Fig. 1-B) its corrective forces are mobilized. The details of construction are referred to in the text.

thoracolumbar scoliosis (Figs. 1-A, 1-B, 2, and 3). The mechanism would be reversed for a left lateral curvature of the spine in the same region. It is constructed best on a plaster model made with the patient standing and the pelvis leveled. As much correction as possible is obtained by head traction and by three-point pressure against the lateral curvature. The front-lace celluloid base, molded over the iliac crests, grips the pelvis and buttocks snugly. All metal employed is surgical steel, except the soft iron tips which are used for the axillary crutches. Bar *a* (11/16 by 5/32 inch) lies just to the right of the midline and is attached to the celluloid

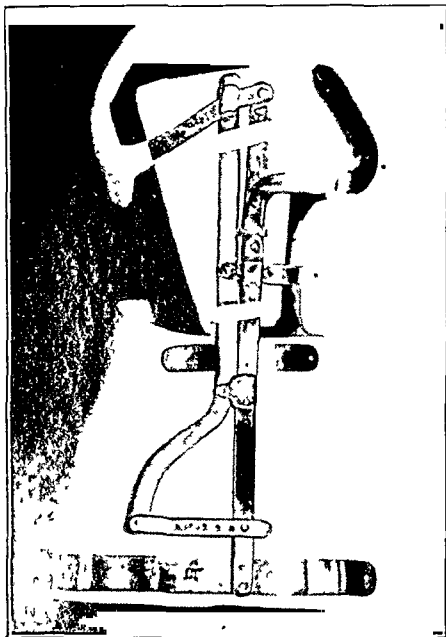


FIG. 2

Fig. 2: The completed brace, constructed for a case with a partially flexible right thoracolumbar scoliosis.

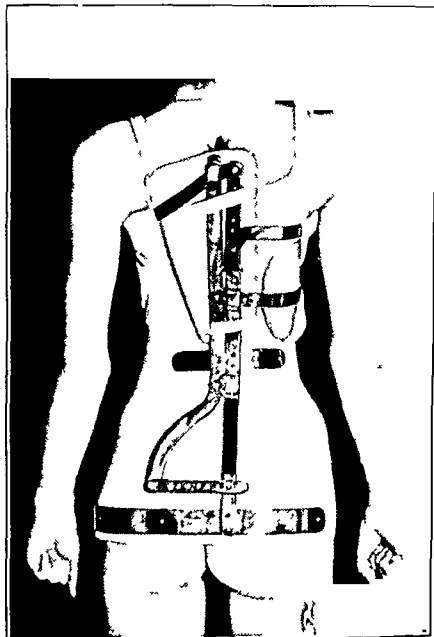


FIG. 3

Fig. 3: Brace applied to a fifteen-year-old girl with a severe right thoracolumbar and left lumbar scoliosis associated with a spina bifida occulta involving four or five midthoracic vertebral segments. Some correction has already been obtained by proper construction of the plaster model, prior to active use of the three-point-pressure unit.



FIG. 4-A

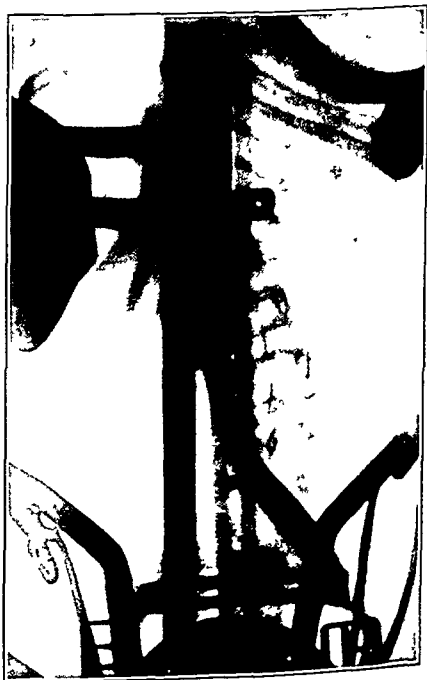


FIG. 4-B

base by bands *b* (1 by  $\frac{1}{8}$  inch) and *c* ( $1\frac{1}{4}$  by  $\frac{1}{8}$  inches). The latter, *c*, extends just beyond the anterosuperior spine of the pelvis on the side opposite the convexity of the scoliosis to permit the attachment of a thigh piece when this is necessary. Free joints are present at *x*, and there are simple screw fixations at *y* to allow for adjustments. As the lower lever of the movable V-shaped rod *d* ( $11/16$  by  $\frac{1}{8}$  inch) approaches the fixed bar *a* through the adjustable bar *e* ( $11/16$  by  $\frac{1}{8}$  inch), the upper and longer lever of *d* moves in an opposite direction. The efficiency of the short, lower lever is increased by the greater angulation between this arm and bar *a*. Movement of the upper lever of *d* away from the midline causes the large galvanized metal pad *f*, which is molded accurately over the apex of the scoliosis, to move towards the midline, as adjustable bar *g* ( $11/16$  by  $\frac{1}{8}$  inch) passes through a guide. At the same time it forces the curved bar *h* ( $11/16$  by  $\frac{1}{8}$  inch) upwards as it glides within the guide *i* at the upper end of bar *d*. The axillary crutch *j* and the small galvanized metal pad *k* are so constructed as to exert pressure against the upper torso and to elevate the left shoulder. The axillary crutch *l* serves to hold the opposite shoulder backwards. The parts of the brace contacting the skin are covered with soft leather and are padded with white felt or lined with molecloth.

Adjustment of bar *e* causes increased pressure against the apex of the primary lateral curve and contralateral pressure against the torso and beneath the opposite axilla. By adjusting bar *g*, these two forces may be activated independently. With the pelvis fixed within the celluloid base, the effect will be not only to diminish the scoliosis, but also to correct an ipsilateral transposition of the trunk, although when the latter deformity is severe it may be necessary to attach a thigh piece. Maladjustments as a result of growth are corrected by adjusting the length of bars *a* and *d* (these bars may be made excessively long initially or segments may be added), and by elevating the positions of bars *g* and *h*, guide *i*, and axillary crutch *l*.

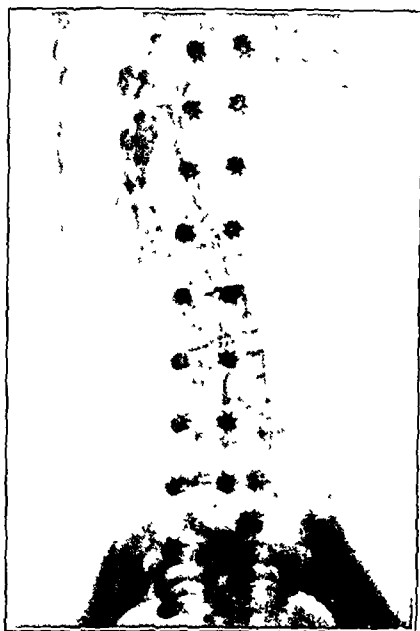


FIG. 4-C

Right thoracolumbar scoliosis (idiopathic), with transposition of the upper trunk to the right, in a thirteen-year-old girl. Anteroposterior roentgenographic views show condition before application (Fig. 4-A); after application of the unopened brace (Fig. 4-B); and one year after the use of the active three-point-pressure unit. A celluloid jacket has been applied to maintain the correction of approximately 25 degrees in the primary lateral curve.

# A METHOD FOR MAINTAINING THE CUT EDGES OF SPLIT AND BIVALVED CASTS IN ACCURATE APPPOSITION

BY R. CLAYTON ROUNDS, M.D., DENVER, COLORADO

*From the Children's Hospital, Denver*

Adhesive tape or cloth straps are commonly used to maintain in apposition the cut edges of bivalved and split casts. However, where it is necessary to remove the cast frequently to exercise or massage the immobilized part, adhesive closure becomes a messy, expensive procedure. Cloth straps, although inexpensively and rapidly applied, frequently fail to maintain the sections in good approximation and produce overlapping or telescoping of the cut edges. The following method eliminates adhesive and cloth strapping, and maintains the cut edges of the cast in accurate apposition.

## TECHNIQUE

Two plaster splints, four by fifteen inches, are folded longitudinally

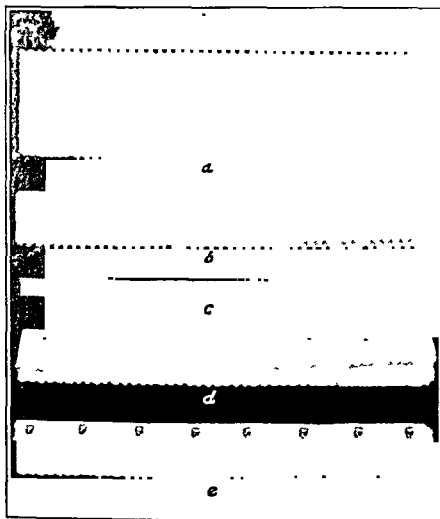


FIG. 1

Photograph illustrating method of preparing boot-hook strips.

- a: Hard-coated, rapid-drying plaster splints.
- b: Splints folded longitudinally.
- c: Webbing reinforcement.
- d: Webbing inserted and holes punched to receive boot hooks.
- e: Finished strip.

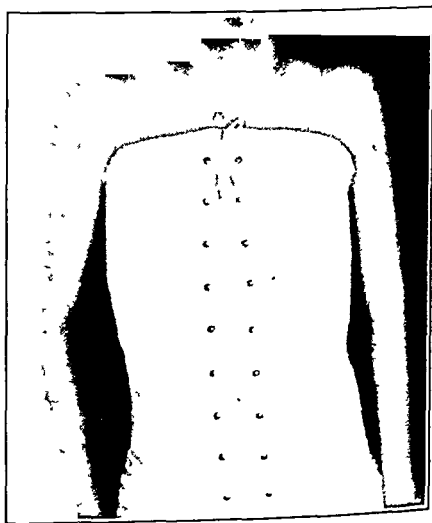


FIG. 2

Plaster body jacket split and laced.

along the midline over a webbing or canvas strip three-fourths inches wide, as shown in Figure 1. Holes are then punched at two-inch intervals along the folded border about

one-half inch from the edge. Through the punched openings nickel-plated boot hooks are inserted and cinched in place. When needed, the



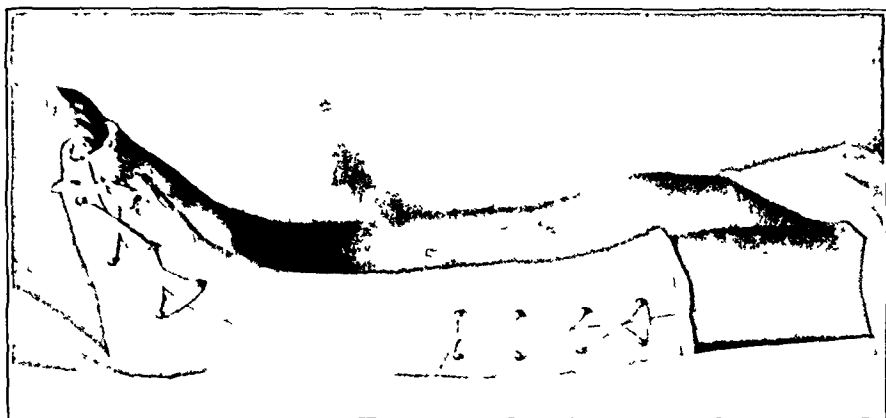


FIG. 3

Bivalved leg cast with anterior and posterior shells laced together.

entire strip or as much as desired is dipped in water and applied to the moistened and roughened cast and rubbed well to eliminate all air bubbles and insure permanent union of the hook strip to the cast. A second strip, having the same number of hooks, is applied in a similar manner to the other section of the cast with the hooks opposite each other. The plaster is then allowed to dry thoroughly, preferably for twenty-four to forty-eight hours before the lacings are applied.

#### COMMENT

Although the hooks may be applied to any type of cast desired, the method has been used to best advantage in the apposition of the edges of split casts (Figs. 2 and 3) and, in particular, split body jackets. It has also been very useful in fixing and maintaining the position of bivalved arm or leg night shells in young and active children. It is important that the plaster be perfectly dry before the lacing is applied, for if applied too early there is a tendency for the plaster to crack about the hooks, and loosening may occur.

At the Children's Hospital, where this method has been in use for about ten months, the boot-hook strips are prepared by the older patients in the Department of Occupational Therapy, and a supply is kept on hand in the plaster room to be available when needed.

# ACCESSORIES FOR WEDGING PLASTER JACKET IN THE TREATMENT OF SCOLIOSIS

BY C. W. GOFF, M.D., AND J. H. ALDES, M.D., HARTFORD, CONNECTICUT

*From the Newington Home for Crippled Children, Newington, Connecticut*

Pragmatism should govern the orthopaedic surgeon in his treatment of scoliosis, a costly deformity both to the patient and the surgeon. To cut down this burdensome process to a minimum, the following steps have been developed over a four-year period, during which the turnbuckle and wedging plaster jacket, as described by Smith, Butte, and Ferguson<sup>1</sup> has been used in the corrective treatment of scoliosis. No attempt will be made

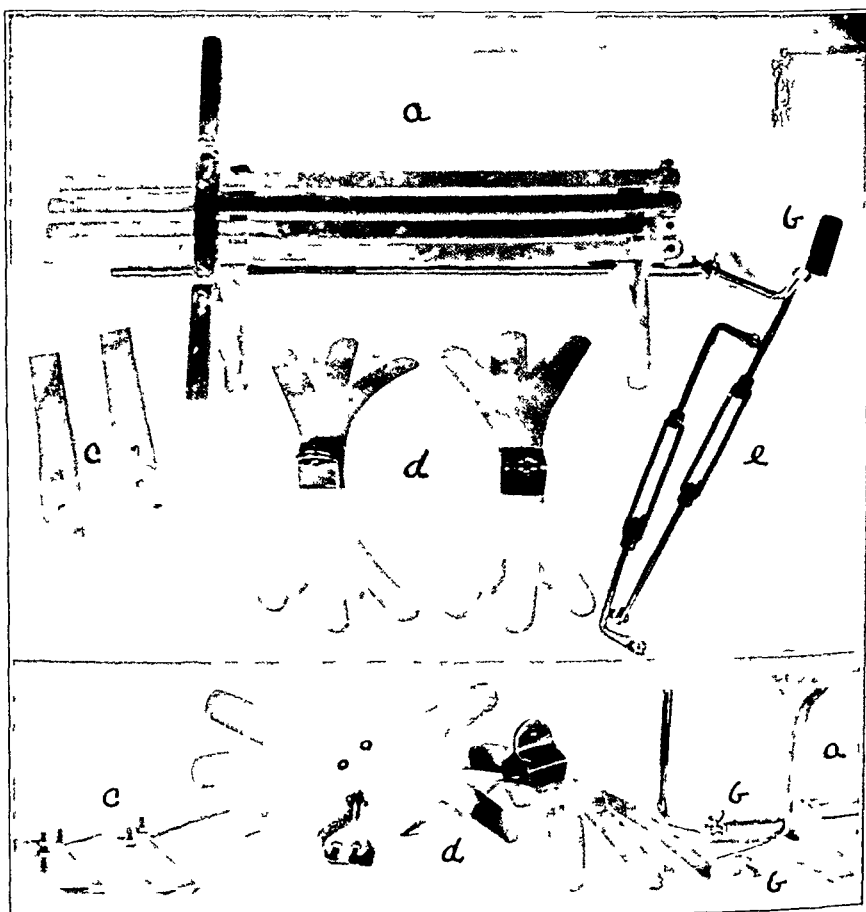


FIG. 1

Hardware modifications. *a*: Goldthwait frame with head support. *b*: Demonstrates use of frame to steady head during incorporation of patient in plaster jacket. *c*: Duralumin hinges drilled to take two-inch stove bolts. *d*: Removable holders. Note how the parts are separated; flanged portion is incorporated in plaster and turnbuckle attachments bolted on when plaster is cut, after three to five days' drying. *e*: Turnbuckles, ends bent and drilled for bolts.



FIG. 2-A  
Posture pictures before treatment.

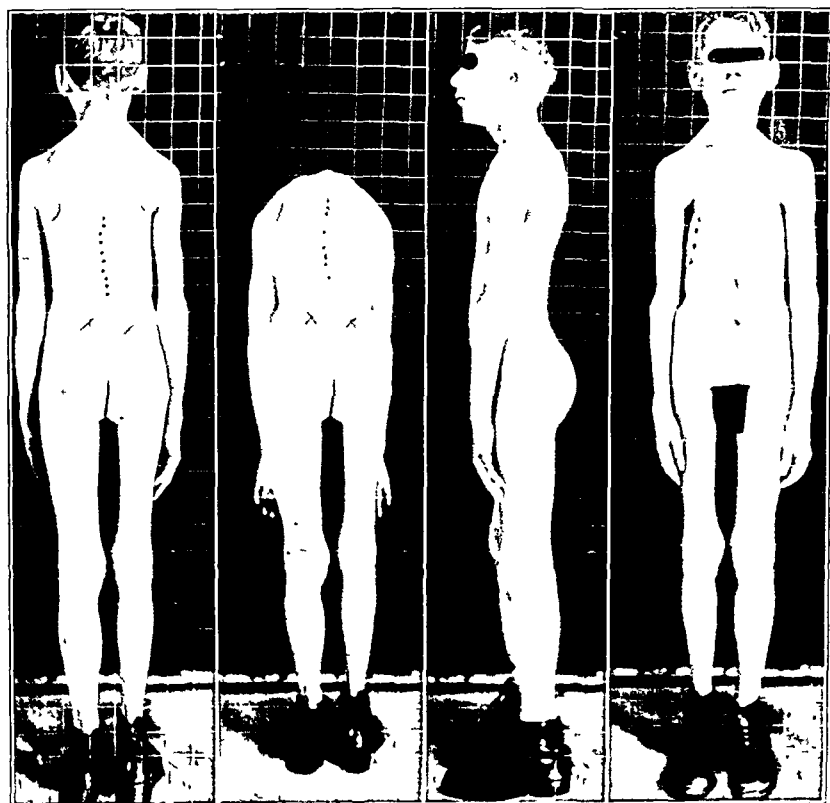


FIG. 2-B  
Posture pictures after treatment.

to quote the voluminous literature or to go into the theory of treatment. This is a personal report of practical points found useful and effective.

Posture pictures are taken before treatment is begun, and, again,

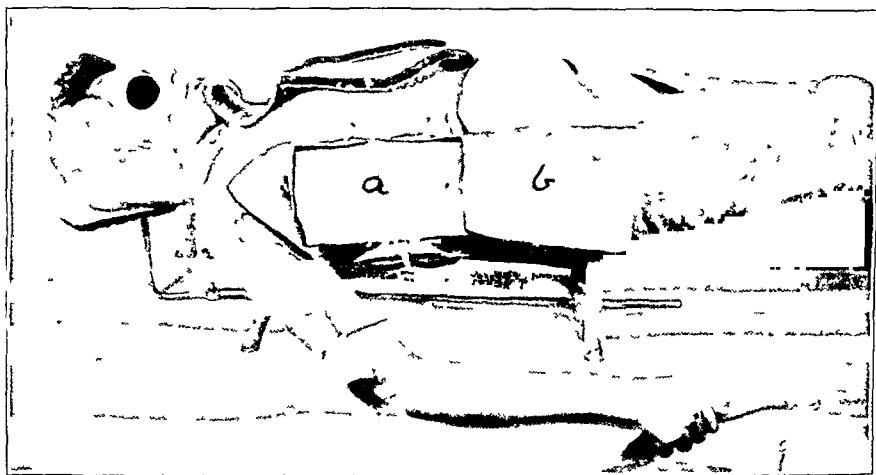


FIG 3

First jacket is applied over felt garment as shown. Extra heavy felt pads are placed over bony prominences and beneath hinges, as well as two oblong pads on the side away from the turnbuckle. These pads (a and b) are removed when plaster is wedged and before correction is begun. Note longitudinal felt strip under chin and pad under occiput. Goldthwait frame with modification is used to support head during application of jacket



FIG. 4

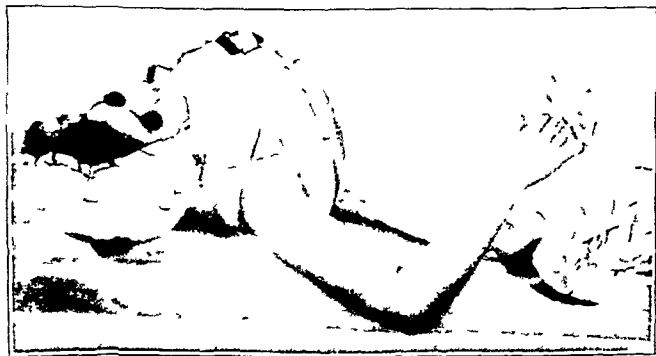


FIG. 5

Fig 4. Completed plaster jacket is painted with white ducro and the margins are neatly taped. Correction is progressing with comfort to the patient.

FIG. 5: Plaster has been cut away under the axilla and a special sling substituted which is attached to the front and back hinge bolts. Maintenance of correction is easily secured.

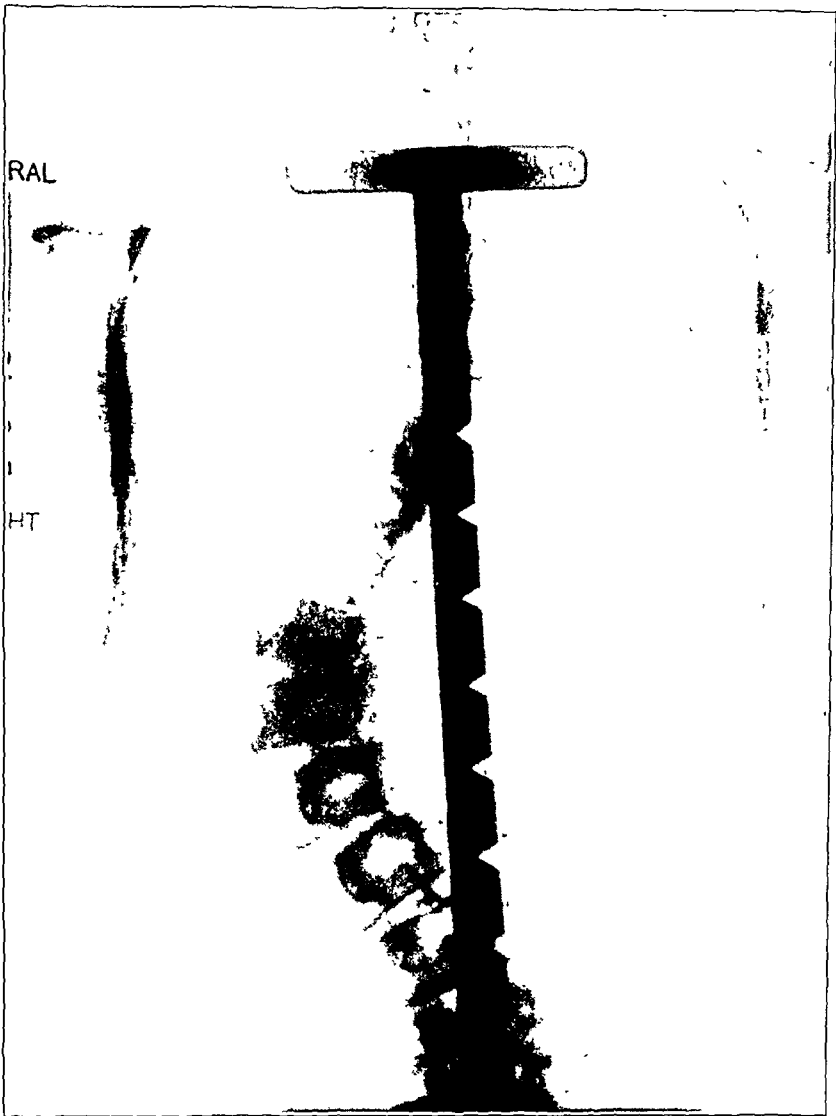


FIG. 6

Roentgenogram showing marker to locate apex of primary curve for placing hinges.

after it has been completed (Figs. 2-A and 2-B). These are taken through a thread screen.

Roentgenographic studies are made with the patient standing in several positions, or sitting with a two-inch block under alternately the left and right buttocks, to determine the location, extent and correctibility of the primary curve at onset of treatment, and to show the strength of fused area after treatment has been completed.

Hardware modifications that have proved their worth consist of duralumin hinges with two-inch stove bolts, incorporated in plaster, on each side of rivet. The nuts are tightened to fix the hinge securely to the

jacket walls. Such a hinge does not pull out under corrective leverage. The attachments for the turnbuckle are in two parts which are bolted together as illustrated with the flanged portion embedded in plaster, and the protruding piece bolted on later for security. Turnbuckles are bent at their ends and drilled to take a small bolt.

The Goldthwait frame is modified to include an extension which will hold the head, during the application of the jacket, toward the side on which the turnbuckle is to be placed (Fig. 1).

A thin felt garment is cut and fitted to patient over cotton stockinette, and is padded over all prominent parts, especially beneath both hinges and on the side away from the turnbuckle. These last two pads are removed when plaster is cut, and before correction is begun. This additional space allows the thorax to push into that side and helps correct the gibbosity. A strip of felt placed longitudinally under the chin gives great comfort to the patient (Fig. 3).

Including the thigh in plaster on the side of the turnbuckle has reduced pressure sores to a minimum, and has appeared to be more efficient than including the opposite thigh. Thus the pelvis is fixed where leverage and pull are greatest. After cutting and trimming, jackets are taped about the margins. This is followed by a coat or two of white duco paint to preserve the plaster (Fig. 4).

Plaster against the thorax beneath the axilla on the side opposite the turnbuckle gave rise to many complaints until a sling was substituted toward the latter half of the correction period. The sling is made of substantial webbing covered with felt and stockinette, attached to the jacket with leather tabs, and buckled in front. The ends of the sling are fastened to the bolts of the upper arm of the hinges through a grommet in leather tabs. This sling has proved its worth beyond that of any other modification improvised (Fig. 5).



FIG. 7

Jacket is fenestrated to expose area for fusion. In this illustration, patient has had the first stage of fusion of five dorsal vertebrae and is awaiting the second stage of fusion. Turnbuckle is left in place for additional support.



FIG. 8

Roentgenogram showing iron side bars, fenestrated jacket, and hypodermic needle with a portion cut off (at arrow) in eighth dorsal vertebral spinous process. This permits easy identification of vertebrae at time of fusion.

The hinges should be placed just off midline and directly over the apex of the curve to be corrected. This was most difficult to accomplish with accuracy. To aid in placing the hinges, a strip of steel, notched at inch intervals, was placed at the tip of the chin over the anterior chest wall extending toward the xiphoid. A roentgenographic plate was exposed for an anteroposterior view, and the point of the apex of the curve was easily determined. This same strip then is used to locate hinges at the time of application of the jacket (Fig. 6).

The back of the jacket is cut out between strips of soft strap iron

which have been bent and incorporated in the plaster to reinforce the sides. Fenestration of the back of the jacket permits easy access for operative fusion (Fig. 7). A No. 22 hypodermic needle is driven through the cleansed, anaesthetized skin of the back, into the spinous process of a vertebra near the apex of the primary curve. This affords a ready identification of the vertebrae at time of fusion (Fig. 8).

The first jacket, applied the third month after fusion, is of plaster, as may well be the second jacket. The first jacket has supports over both shoulders and is applied on the Goldthwait frame. The second jacket is applied erect with head traction. The final jacket is of celluloid, and is worn for one year. This is made of six layers of stockinette or eight layers of crinoline, with two coats of celluloid between layers. Hooks are sewed up the front, and the jacket can be removed for bathing, etc.

The average patient in the first series of twelve cases was hospitalized for fifty-five weeks at a cost of \$1050. The next twelve averaged sixty-two weeks in hospital at \$1200 and the third series fifty weeks at \$950. Time for correction has been cut down gradually, and, as we approach our fiftieth case, we can anticipate a hospitalization of forty-six weeks at a cost of \$870, which is within reason. This does not include cost of precorrection treatment, or treatment rendered after the child has been discharged from the hospital.

1. SMITH, A. DEF.; BUTTE, F. L.; AND FERGUSON, A. B.: Treatment of Scoliosis by the Wedging Jacket and Spine Fusion. *J. Bone and Joint Surg.*, XX, 825, 1938.



## NEW ISCHIAL SEAT BRACE FOR ELIMINATION OF WEIGHT-BEARING

BY HENRY H. JORDAN, M.D., NEW YORK, N. Y.

More than half a century ago E. G. Brackett improved the Dowse splint for the lower extremity by using a "perineal band", consisting of three adjustable leather straps, for transmission of weight from the pelvis to the ground. This successful construction was recently rediscovered by H. v. Baeyer who, in 1937, described the following modification of the same principle. The new *leather-strap* ischial seat has considerable advantages for both the patient and the bracemaker, and is, therefore, recommended for general use in a wider variety of conditions calling for the elimination of weight-bearing.

The leather-strap seat transfers the body weight from the tuber

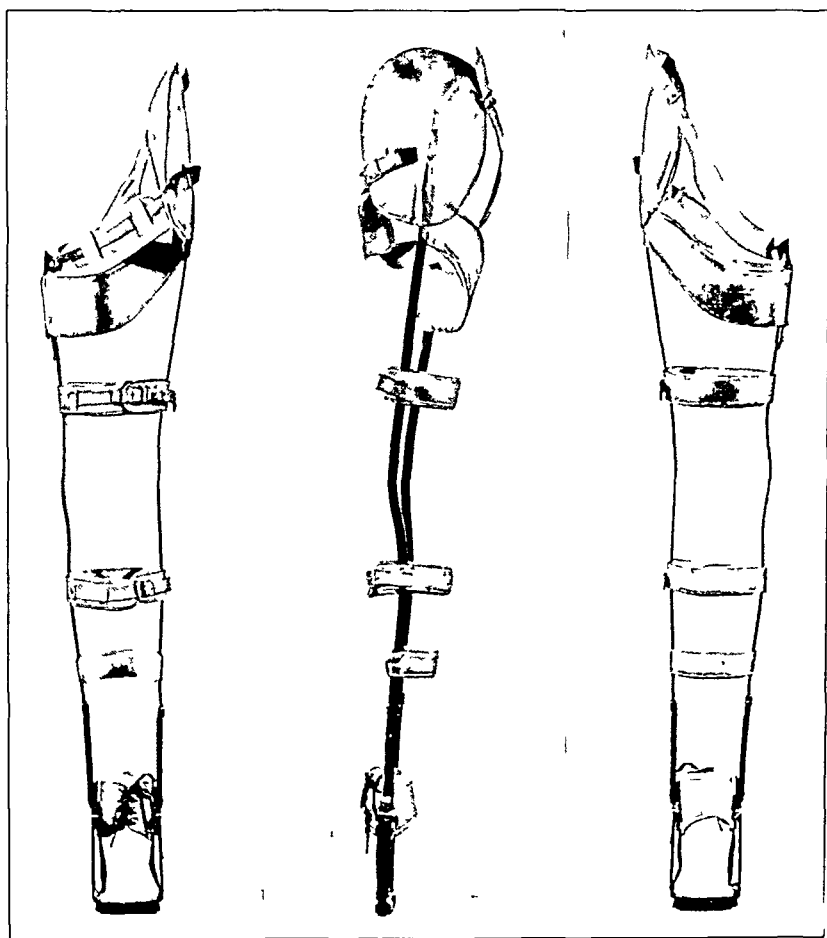


FIG. 1

ischii and the lower ramus of the ischium to the *lateral* upright longitudinal bar of a double-bar leg brace; thus the construction differs in two important points from the other known "unweighting" braces. First, a soft leather strap replaces the rigid, and necessarily more bulky, ischial seat of the Thomas ring, or the Hessing brace, or the Galland type of construction. On standing and walking, the tuber ischii rests securely in the leather loop which naturally conforms to the shape of the body and causes no irritation at the perineum. This is still more important for the sitting position which, with any one of the rigid seat constructions, means considerable discomfort. Moreover, the introduction of a leather strap as a weight-transmitting seat makes the building of this type of brace much easier.

The second feature wherein the leather-strap seat brace differs from other constructions is the suspension of the weight at the proximal end of the *external* longitudinal bar at a level above the trochanter. This calls for great strength of just one bar, while the other elements of the brace

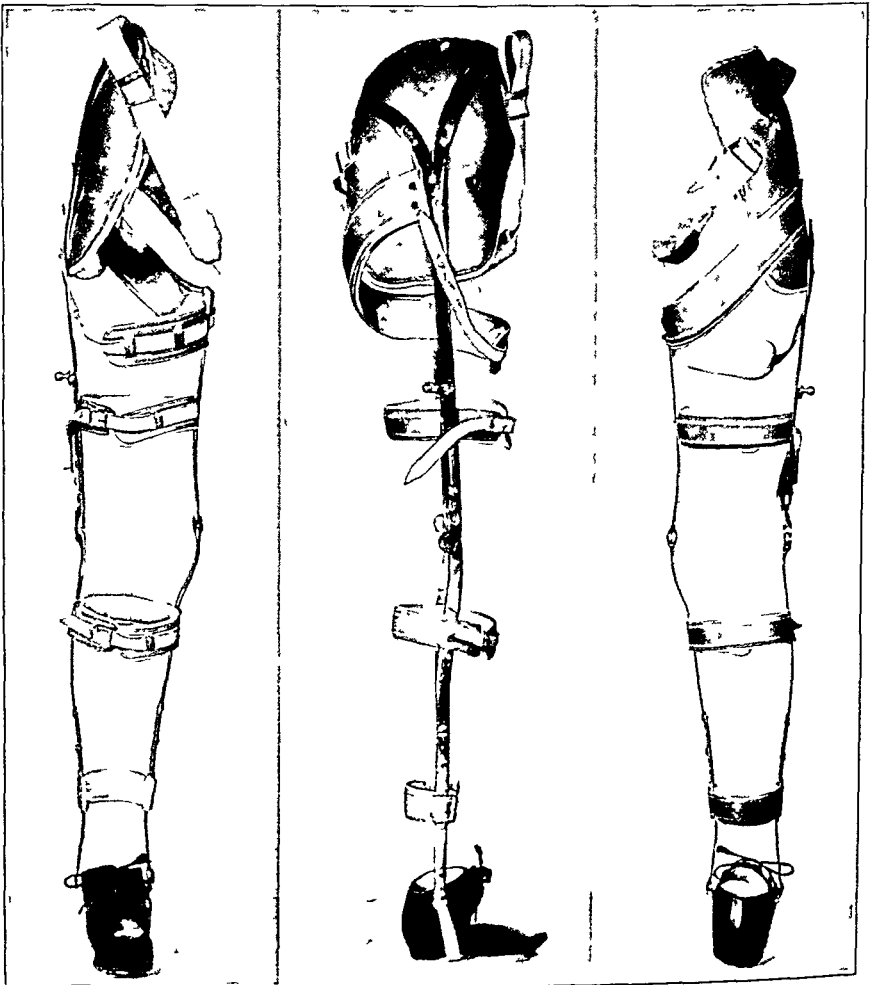


FIG. 2

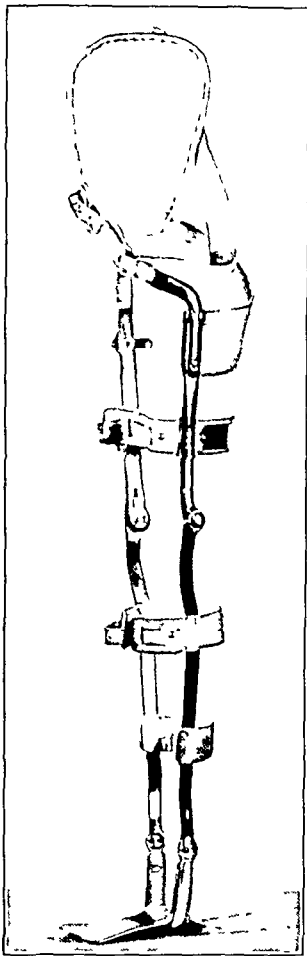


FIG. 3

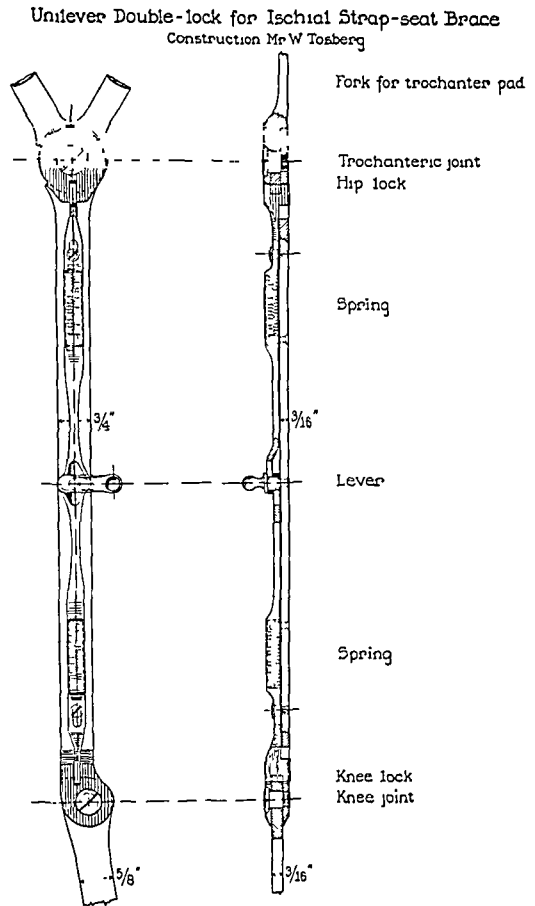


FIG. 4

may be rather light. The medial upright ends far below the perineum, and the proximal semicircular band connecting the two uprights may run far below the gluteal fold. The support of the body weight by the seat strap introduces a force which tends to keep the brace the closer to the body, especially in the region of the trochanter, the more weight is placed on the seat. This makes auxiliary forces, such as a pelvic band, superfluous.

The leather-strap seat lends itself to practically every type of brace construction one might select for the needs of the individual patient. In its most primitive form the ischial strap-seat brace may be built as a jointless brace with a patten (Fig. 1). The ischial strap seat may be incorporated into any double-bar leg brace with ankle joint and stirrup or sandal, provided there is a lock at the knee joint (Fig. 2).

Pressure of the strap on the adductor muscles can be avoided by adding to the proximal end of the medial upright a rectangular bar. One end of the leather strap is riveted to its horizontal arm (Fig. 3).

After the patient has worn the brace for some time, it is possible to trim the trochanteric pad as much as two inches without losing its "unweighting" effect. Where skilled labor is available, and the expense is of minor importance, the brace may be built with a *trochanteric lock joint*. For this purpose a unilever double lock was designed by W. Tosberg, which is a modification of the joint known in the literature as the O. I. (*Orthopaedische Industrie*) knee lock joint. The small lever which operates the knee lock simultaneously operates the lock for the trochanteric joint, and on sitting down the hip and the knee joint may be flexed in a normal manner (Fig. 4).

The development of the ischial strap-seat brace into an appliance which is inexpensive, easy to manufacture—if necessary within one day—and guarantees an efficient "unweighting" of the lower extremity without the usual discomfort to the patient, has widened the field for its use. The simplest form of the strap-seat brace has proved extremely satisfactory in a series of cases of slipped femoral epiphysis, especially when applied in the so-called preslipping stage, and in Perthes' disease. The more elaborate double-bar leg brace with the strap seat and lock joints has been successfully used in the treatment of patients with arthritis of the hip joint, chiefly the unilateral *malum coxae senilis*. Another group, for which this brace may be recommended, are the aged patients with fracture of the neck of the femur.

The ischial strap-seat brace is equally useful when the lesion requiring treatment is at the knee or foot section of the leg.

#### SUMMARY

An ischial seat brace for "unweighting" the lower extremity introduces a leather-strap seat. The new construction principle simplifies the manufacture and fitting of an ischial seat brace, eliminates various known causes of discomfort to the patient, and thus widens the field for the use of an ambulatory orthopaedic appliance.

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# A GUIDE FOR DRILLING UNUNITED FRACTURES

BY PETER G. SHIFRIN, M.D., DETROIT, MICHIGAN

The operation of drilling multiple drill holes across a fracture line for delayed healing or non-union has met with sufficient success to remain as a permanent procedure in the armamentarium of the surgeon. However a few technical details have always been a source of annoyance in carrying out this procedure. One is that unless the puncture incision is made large enough, the drill, especially a motor drill, injures the skin edges. If the incision is large enough, say one-half to three-fourths inch, retraction by an assistant with small retractors is clumsy, particularly if direct fluoroscopic observation is undertaken at the time the drill is trav-

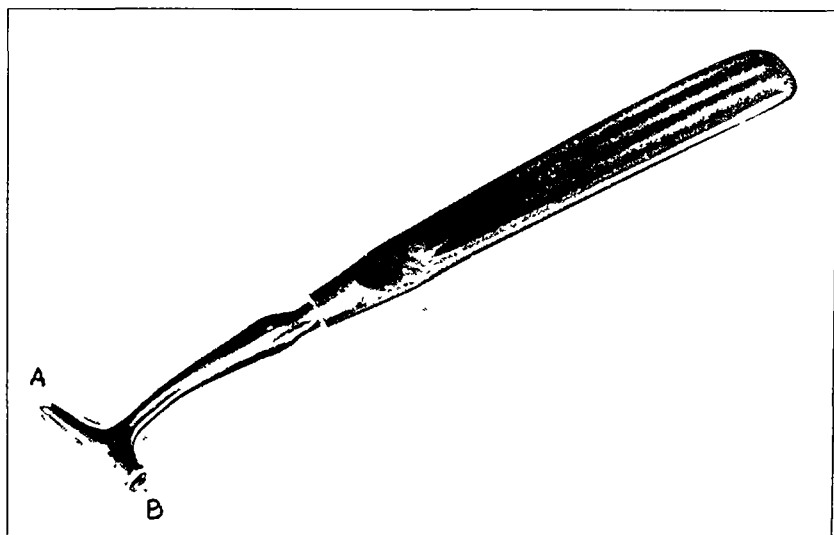


Fig. 1

ersing the fracture line. Another point of difficulty encountered is, after one or two divergent holes are made from one starting point, it is hard to start more diverging channels from the same point, since the drill tends to slide into the previously made channels.

The instrument here presented (Fig. 1) overcomes these difficulties with remarkable success. It consists of a tempered steel tube of one or one and one-half inches in length, and one-fourth inch in diameter on the outside, which will admit with slight play a three-thirty-seconds-inch drill bit. The upper end (B) of the tube is slightly beveled on the inside; the lower end (A) consists of three sharp prongs, beveled from the inside.

Its use is simple. After infiltrating with local anaesthetic a small area above and below the line of fracture, down to the periosteum, quarter-inch stab incisions are made. End A of the instrument is inserted

through the wound to the bone surface. With the instrument held at whatever angle of inclination is desired, a firm tap with a mallet over end *B* will engage the prongs. The direction may now be checked under a fluoroscope. The instrument is held with the left hand, while the right hand operates the electric drill; or the instrument is supported by an assistant if a hand drill is used. The guide is now disengaged, the direction changed, and the procedure repeated.

Ordinarily the one-inch tube is sufficiently long to reach through the soft tissues to the bone; however, on femora, and in other locations on very muscular or fat individuals, the one-and-one-half-inch tube will be required.

## SELF-ILLUMINATING PATELLA RETRACTOR

BY MILTON C. COBEY, M.D., WASHINGTON, D. C.

An excellent view of the knee joint, as well as its illumination throughout, is obtained by the use of a knee retractor, made from lucite and modeled from a steel patella retractor originally designed by George E. Bennett, M.D., Professor of Orthopaedic Surgery, Johns Hopkins Hospital.

The retractor is so constructed that it easily slides under the articular surface of the patella, and conforms to this surface in such a manner that it does no harm. In this position the retractor holds the patella upwards and laterally or medially as desired, thus adequately exposing the articulating surfaces of the knee joint and of the quadriceps pouch.

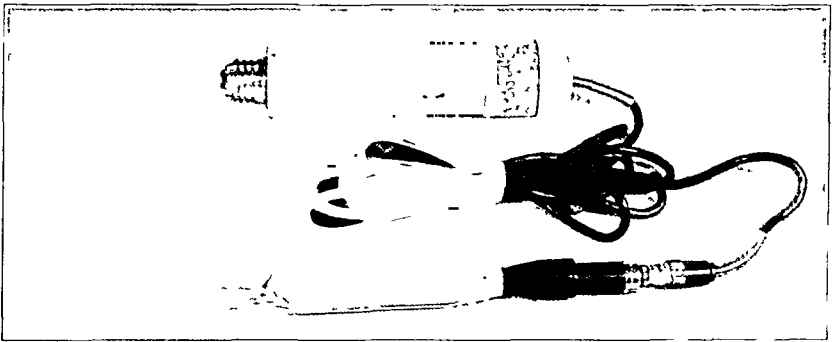


Fig. 1

Lucite allows the passage of light throughout its entire length. Forty per cent. of the light is given off at the elbow, and 60 per cent. at the end of the retractor. The cord, bulb, and adaptor of the light outfit are boilable. However, as lucite softens and cracks after several boilings, the retractor is rendered aseptic best by cold sterilization. Bacterial studies have shown that cold sterilization is satisfactory and quite safe. The material is not easily broken, and has an added advantage over glass,—under strain it will bend before it breaks. However, under normal use in an operation upon the knee, there is no excuse for the retractor to bend.

This illumination of both the medial and lateral surfaces of the joint from the incision affords a clear visual examination of the articular surfaces and quadriceps pouch. It is particularly useful in exploring a joint for loose bodies, foreign bodies, and the cartilaginous plaques of osteochondritis dissecans. It is also most valuable in synovectomies through the utility type of incision, particularly in making visible the synovial membrane on the far side of the wound.

## ALBERT H. FREIBERG

1868-1940

Dr. Albert H. Freiberg died in Cincinnati, July 14, 1940, after an illness of two weeks. He was born in Cincinnati, August 17, 1868, the son of Joseph and Amalia Freiberg. He is survived by his wife, who was Jeannette Freiberg, and two sons, Joseph A., who was associated with him in his practice, and Albert M., who is an attorney.

He was a graduate of the University of Cincinnati and of the Medical College of Ohio, which later became the Medical College of the University. After his internship at the General Hospital he spent considerable time abroad, studying at the universities of Würzburg, Strasbourg, Berlin, and Vienna. On his return to this country in 1893 he began practice in Cincinnati, and, as was the custom in those days, he began with general work, but his aim always led him toward specializing in orthopaedic surgery.

Dr. Freiberg always took an active part in the affairs of his profession and was a member of the American Medical Association, the American Orthopaedic Association, the Clinical Orthopaedic Society, and a Fellow of the American College of Surgeons and of the American Academy of Orthopaedic Surgeons. He was also active in local medical affairs. He was President of the Ohio Medical Society, 1929-1930; the Cincinnati Academy of Medicine, 1923-1924; and Chairman of the Orthopaedic Section of the American Medical Association, 1917-1918. Dr. Freiberg played an important part in the establishment of orthopaedic surgery in his city and state, and the present position of orthopaedic surgery in that community is largely due to his influence and the result of his work. He was Chief of the Orthopaedic Service at the Cincinnati General Hospital, at the Children's Hospital, and at the Jewish Hospital while in active practice, and continued to serve as consultant at these hospitals. At the time of his retirement from the Chair of Orthopaedic Surgery at the Medical College of the University two years ago, he was made Professor Emeritus. During the World War he served as Major in the Medical Corps, United States Army, and was Chief of the Department of Orthopaedic Surgery at Walter Reed Hospital at that time.

Dr. Freiberg always took a special interest in the affairs of the American Orthopaedic Association, particularly in its development, to the end that it might be an important and influential factor in establishing and maintaining a high and dignified standard. He was President of the Association for the year 1910-1911 and always took an active part in the scientific and administrative proceedings of all of its meetings, and served on many important committees. In the executive meetings Dr. Freiberg was frequently consulted on matters of parliamentary law. His mind was keen and analytical, his judgment fair and tinged with kindness. He was a splendid speaker and his tongue had no barb. He was influential in debate and frequently turned the discussion toward a correct and wise decision. His honesty and good sense added weight to his opinions. He took a prominent part in its scientific sessions and the Association always looked forward to his communications as being of value for they indicated the result of his experience and excellent judgment. His position was always foremost in the advance line of progress.

He was an active contributor to medical literature. He showed a good deal of originality, and was always foremost in aiding advancements which came to orthopaedic surgery through the enlargement of the field of surgery resulting from the advent of antiseptic surgery. He kept in close touch with the departments of medicine other than that to which he devoted his life, and he did this on principle as part of his eager quest for knowledge, which was evident in his clear sense of values and breadth of grasp. His consideration of all sides of any problem gave weight and confidence to his decision.

He always gave much of his time and thought to the problem of rehabilitation of crippled children, and was one of the first members of the profession to advocate state aid for their care. He accomplished a great deal in interesting the community and also other states in the solution of this problem and in the establishment of legislation for state aid.





ALBERT H. FREIBERG

He was Chairman of the Advisory Committee on Crippled Children of the Children's Bureau, United States Department of Labor.

Dr. Freiberg was a man of broad interests, not wholly confined to medicine. He always took time to occupy himself with affairs outside of his profession, and had the courage to give himself opportunity for the expression of his love of music, in which he was proficient, and for many years he played weekly with his orchestra. He was also interested in education and art and was a member of many committees and societies. The finer influence of the arts was evident in the sum total which gave to him his distinctive qualities.

His contribution to the social gatherings of the Association was a prominent and expected feature. He will be greatly missed and will always be in our memory.

## AUGUSTUS THORNDIKE

1863-1940

Dr. Augustus Thorndike died suddenly on August 23, 1940, at his summer home in Bar Harbor, Maine, at the age of seventy-seven years. His wife, the former Alice Amory of Boston, whom he married in 1892, died two years ago. They had five children, who survive him: Mrs. Lyneham Crocker, Mrs. Alexis Sommarina, Dr. Augustus Thorndike, Jr., Charles Thorndike, and Robert Amory Thorndike.

He had devoted the entire period of his medical career to orthopaedic surgery and contributed frequently to the orthopaedic literature. He was the author of "A Manual of Orthopedic Surgery" which was adopted for use in many medical schools.

Dr. Thorndike became a member of the American Orthopaedic Association in 1893, was in regular attendance at its meetings, and interested himself in its administration and scientific proceedings. He served as its President for the year 1909-1910, presiding at the Annual Meeting held in Washington, D. C., and continued to take an active interest in its affairs. The welcome accorded him at the Association meetings was evidence of the high esteem in which he was held by all the members.

He was born in Paris, but received his education in the community in which he always lived. He was a graduate of Harvard College in the Class of 1884, and of Harvard Medical School in the Class of 1888. After finishing his early medical education, he served as an Intern on the Surgical Service of the Massachusetts General Hospital, and later was Intern at the Boston Lying-In Hospital and at the House of the Good Samaritan.

After completing his preliminary training, he established himself in the practice of medicine in Boston, and from the first he occupied himself with the problems of orthopaedic surgery. During the time of his service at the House of the Good Samaritan he became interested in the special care necessary in the treatment of the crippled child. At that time a large proportion of the cases were tuberculous, and, because of the fact that hospital equipment was then meager, these children required a great deal of careful attention and personal supervision from those who were in surgical charge. From the beginning of his work in this Hospital, Dr. Thorndike showed his capacity for conscientious care and his sympathy for these children, which were demonstrated by the success which he had with these difficult and protracted cases. He was also visiting surgeon in the Orthopaedic Department of the Boston Dispensary and at St. Luke's Home for Convalescents to which he gave freely of his time and effort.

During the entire period of his active practice, Dr. Thorndike served as a member of the Staff of the Boston Children's Hospital. It was this institution to which he devoted the greatest amount of his time and energy. Such a service, at that time, to be performed faithfully, required devotion and sacrifice of personal interests, and his contribution to this Hospital was a very prominent feature. It was characterized by his unusual dependability and by his careful and painstaking attention, not only to the surgical care of the children but also to their general interest, and he was untiring in his efforts to bring the best to this group of children.

Dr. Thorndike was always especially interested in the problem of the crippled child, and occupied himself very largely with its solution,—not only as to medical and surgical care, but toward providing opportunities to offset the loss of those advantages of which they were so often deprived because of their infirmities. He was particularly interested also in the provision for their education and for manual training, to be given with the object of fitting them for some gainful occupation. He was one of the incorporators of the Boston Industrial School for Crippled Children and served as a member of its Board of Directors as well as of the medical Staff during the early period of its establishment, and he was influential in the conduct of its affairs in its later growth. He also took part



AUGUSTUS THORNDIKE

in the establishment of the State Hospital School for Children at Canton which was organized some few years after the incorporation of the School for Crippled Children.

He was a member of the American Medical Association, a Fellow of the American College of Surgeons, and also an active member of many societies in his community,—the Massachusetts Medical Society, the Society of Medical Sciences, and the Boston Medical Benevolent Society. He was also interested in the Boston Medical Library.

Dr. Thorndike's helpful attitude toward his associates, and particularly with his coworkers, was an outstanding feature of his character, and he gave freely of himself. He was just in his estimate of people, free from criticism, and tolerant toward the opinions of others. He was a good friend and had a philosophy of life that drew all to him.

# News Notes

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Word has been received of the death of Mr. R. C. Elmslie, of London. A more extended notice will be included in the next issue of *The Journal*.

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The Annual Meeting of the **British Orthopaedic Association** will be held in Liverpool on October 25 and 26.

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Dr. Austin T. Moore announces the opening of The Orthopedic Hospital and the Moore-Green Clinic at Gervais and Pickens Streets, Columbia, South Carolina.

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The Annual Roll Call of the **American Red Cross** to enlist members for 1941 will be conducted throughout the nation from November 11 to 30, 1940.

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The Annual Meeting of the **Orthopaedic Guild** will be held in New York City, November 1 and 2, under the chairmanship of Dr. Robert L. Preston.

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The next examination of the **American Board of Orthopaedic Surgery** will be held at New Orleans in January 1941, just preceding the meeting of the American Academy of Orthopaedic Surgeons. Applications for this examination must be filed with the Secretary, Dr. Fremont A. Chandler, 6 North Michigan Avenue, Chicago, Illinois, on or before November 15, 1940.

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The **Buckeye Orthopaedic Club** of Ohio was formed in Cincinnati on May 14. The Club plans a meeting each year at the time and place of the Ohio State Medical Society meeting, to consider matters of interest to orthopaedic surgeons of the State and to participate in a clinical day. Dr. Albert H. Freiberg was elected the first President, and upon his death in July he was succeeded by Dr. Burt G. Chollett. The Secretary of the Club is Dr. Edward Harlan Wilson of Columbus.

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The Ninth Annual Convention of the **American Academy of Orthopaedic Surgeons** will be held in New Orleans, Louisiana, January 12 to 16, 1941, under the Presidency of Dr. Robert D. Schrock.

The first day will be devoted to committee meetings. Monday, January 13, will be a Clinical Day arranged by Dr. Guy A. Caldwell and his committee. The program for Tuesday, January 14, includes a discussion of new procedures in orthopaedic treatment at the morning session, and, in the afternoon, papers on bone tumors. On Wednesday morning the papers will deal with the progress in orthopaedic surgery, and the afternoon will be devoted to the consideration of fractures. The scientific program will continue until Thursday noon when the second executive session will be held.

Guest speakers at the Meeting will include Dr. Murray Copeland who will speak on "The Classification of Bone Tumors", and Dr. Alton Ochsner whose subject will be "Thrombophlebitis".

A complete program of the Meeting will appear in the January issue of *The Journal*.

# Current Literature

PRINCIPLES OF SURGICAL CARE. SHOCK, AND OTHER PROBLEMS. Alfred Blalock, M.D. St. Louis, The C. V. Mosby Company, 1940. \$4.50.

The regulation of circulation, including blood pressure and cardiac output, has for nearly fifteen years been subjected to critical study, both in the laboratory and in the hospital, by Dr. Blalock and his associates. Out of these studies has been evolved a most complete theory, supported by accumulated data, by which surgical shock might be explained, prevented, or successfully treated.

The results of these studies are reported in this very interesting and instructive monograph of 308 pages. In this monograph Dr. Blalock has discussed anaesthesia, surgical technique, the circulatory system, shock, and fluid and electrolyte balance. In the latter chapters Dr. Blalock has included a review of nutritional disorders, diabetes, hypertension and nephritis, endocrine disorders, and pulmonary or abdominal post-operative complications.

The physician who devotes any considerable portion of his time to surgery, owes it to himself and to all of his future patients, to provide himself with the knowledge, or at least the source book of knowledge, which will make him more alert to detect, prevent, or treat any or all of the multitudinous complications which may follow an operation. For those who wish to so fortify themselves, this book is specifically recommended.

SURGERY OF THE HAND. WOUNDS, INFECTIONS AND CLOSED TRAUMATA. A Book for the Practitioner and the Surgeon. Marc Iselin, M.D. Translated by T. M. J. d'Offay, Ch.B., F.R.C.S., and Thomas B. Mouat, Ch.M., F.R.C.S. Philadelphia, The Blakiston Co., 1940. \$5.50.

This is the first edition of the translation into English of a book, written by a French surgeon, which has reached its third edition in France.

It is a very detailed study of every pathological condition of the hand and fingers. The minutest details of the anatomy, physiology, and pathology of each condition are given with illustrative case histories. There are many excellent drawings and a few photographs.

One gains the impression that some of the treatment advised is too detailed and exacting to be used by the average practitioner. For instance, the only treatment advised for a subungual hematoma is bilateral incision along the nail bed, and removal of all the nail raised by the hematoma,—exactly the treatment advised for a subungual whitlow. However, the author emphasizes the necessity of thorough attention to what may appear to be minor injuries, but which may be disabling for long periods of time.

One of the translators calls attention to the true use of the word “débridement”, which means “enlargement of the wound”. This treatment was first advocated in 1789, before the days of anaesthesia, and then the term did not refer to the procedure now associated with the word,—namely, excision of devitalized tissue.

ORTHOPÄDIE UND KINDERHEILKUNDE. IN AUSGEWÄHLTEN KAPITELN (Orthopaedics and Pediatrics, with Selected Subjects). Prof. Dr. Max Lange. Supplement to *Archiv für Kinderheilkunde*. Stuttgart, Ferdinand Enke, 1940.

This interesting seventy-five page supplement to the *Archiv für Kinderheilkunde* is truly a short cut to children's orthopaedics. The diagnostic material is excellent. The treatment follows the dictates of the Lange school, which is at considerable variance with American treatment. There is no attempt to include any new material. The booklet has little of interest to orthopaedic surgeons but should prove valuable to pediatricians for whom it is intended.

SYNOPSIS OF THE PRINCIPLES OF SURGERY. Jacob K. Berman, M.D., F.A.C.S. St. Louis, The C. V. Mosby Co., 1940. \$5.00.

As its title implies, this new volume is not so much a description of surgical diseases or an exposition of surgical operative techniques as it is a discussion of the correlation of the basic sciences with the fundamental principles of surgery. After a brief review of the history and methods of surgery, it outlines the practical applications of embryology, anatomy, histology, bacteriology, and pathology, and discusses the general aspects of local, specific, and systemic infections. Most important of all, it explains the relation of biochemistry and physiology to the understanding of anoxia, shock, hemorrhage, endocrine dysfunction, and subhydration, and to "the proper evaluation of such states as acidosis, alkalosis, tetany, and calcium imbalance". The brief chapter on acid-base balance may particularly be cited as an admirable example of this type of discussion.

Naturally in a volume relatively so small (615 short pages) and with so wide a field of survey, the descriptions of the surgery of the various body systems is extremely condensed. The chapter on the skeletal system, for example, is by no means a complete treatise on orthopaedic surgery, nor is that on the reproductive and urinary systems an adequate presentation of gynecology and urology. These facts, however, are not faults, but are inherent in the purpose and scope of this admirable work. Especial praise is due also to the excellent illustrations, 274 in number, and to the selected references which are appended to each chapter and which should inspire the student and the practising surgeon to further and original study.

STUDIEN ÜBER 111 NACHUNTERSUCHTE FÄLLE VON CALCANEUSFRAKTUREN UNTER BESONDERER BERÜCKSICHTIGUNG DER GELENKSCHÄDEN ZWISCHEN TALUS UND CALCANEUS. (Follow-up Studies of 111 Fractures of the Os Calcis.) Albert Ahlberg, M.D. Göteborg, Elanders Boktryckeri Aktiebolag, 1940.

This monograph is devoted to the follow-up study of 111 out of a total of 160 os calcis fractures seen between 1925 and 1937. All of the patients were personally re-examined by the author. The results of these examinations have been studied with most meticulous attention to almost all the problems which might arise in the mind of any surgeon. All controversial problems concerning the methods of therapy are discussed in detail. In general, the author favors the closed method of treatment in fresh fractures. He notes that in severely comminuted cases anatomical reposition is not to be expected, even by the methods advanced by Böhler. However, it is pointed out that this is not the invariable prerequisite of good function. Cases in which only fair reposition has been accomplished may have good function, while, on the other hand, those with excellent reposition might have marked disability. In the old cases, subastragalar fusion is recommended for those presenting symptoms of dysfunction.

It would be fruitless to attempt to abstract the information contained within this volume, which is replete with the facts and figures of the most intelligent and painstaking work. In addition to a large and carefully chosen list of references, the histories of all the cases studied are included.

This volume probably presents by far the most critically analytical study of calcaneum fractures which has yet appeared. No one interested in the subject can afford to neglect this excellent treatise.

GRADUATE MEDICAL EDUCATION. Report of Commission on Graduate Medical Education. Chicago, Chicago University Press, 1940.

The methods for promoting graduate education are discussed in the Commission's report from three points of view: that of the intern, the resident, and the practitioner who has been out of medical school for a few years and settled in a country or small town district.

Two influences are operating in these times to emphasize the need for opportunities

for graduate instruction,—namely, the extraordinarily rapid advances being made in biochemistry, physiology, chemotherapy, and immunology, and the efforts of the various specialties to insure the public against inadequately prepared specialists by requiring those desirous of entering a special line of practice to pass a rigid examination, after spending a year or two in advanced studies in the basic sciences and from two to five years in a hospital residency. This latter requirement applies, without much modification, to the individual who has spent a few years in general practice and decides to enter a specialty. No one can deny the advantages and satisfactions to the individual that such a program offers. Over against this must be set the already manifest tendency for those who have fulfilled the almost compulsory requirement of a hospital internship, to supplement that service by a residency, irrespective of whether they plan to enter general or specialized practice. This will delay their engaging in gainful practice until after they are beyond thirty years of age.

For the individual who has established himself in practice and wishes to keep abreast of the advances in medicine but finds it difficult, if not impossible, to give up time to visit the large medical centers for intensive postgraduate study, many of the State Societies are carrying out programs which are brought to the physician's door, through co-operation of medical school faculties, libraries, and local hospitals.

This report provides food for thought to those concerned *about* as well as those who are concerned *with* medical education.

#### MANUAL OF GRADUATE TRAINING IN SURGERY Chicago, American College of Surgeons, 1940

Pursuant to its aim of raising the standards of surgery, the American College of Surgeons has published a twenty-four-page "Manual of Graduate Training in Surgery", in which are incorporated the requirements for its approval of programs of training in general surgery and the surgical specialties in hospitals of the United States and Canada.

The Manual is the outcome of ten years of study of educational programs in surgery by the Board of Regents and several committees of the College. In 1937 a Committee on Graduate Training in Surgery was established, under whose direction the field staff of the College personally surveyed a selected group of hospitals in connection with the work of the Hospital Standardization Department. Based on the findings of those surveys, "Fundamental Principles and Criteria" were developed which have been applied in the evaluation of plans for graduate training in surgery.

The Minimum Standard for Graduate Training in Surgery which is included in the new Manual comprises five clauses, concerned with (1) duration and objective of the program, (2) organization and supervision, (3) basic medical sciences, (4) clinical material, and (5) organized study.

Under the requirements, an acceptable program requires a minimum of two and preferably three or more years of training in surgery, beyond at least one year of general internship. Such preparation is now necessary in order for an applicant for fellowship in the American College of Surgeons to meet the qualifications in respect to training.

Dr. Dallas B. McMaster, Department of Surgery, University of Chicago School of Medicine, is chairman of the Committee.

#### SYNOVIAL (SYNOVIALOMA) OF THE FOOT REPORT OF A CASE William C. Black *The American Journal of Cancer*, XXXIX, 199, June 1940

A synovial tumor of the foot is described. It is thought to be benign and of bural origin. The tumor cells exhibit divergent capacities for differentiation and are associated with a mucinous and cartilaginous matrix. The literature relative to synovial tumors of burae is reviewed. Excellent photomicrographs illustrate the report.—*Grantly W. Taylor, M.D., Boston, Massachusetts.*

CONTRIBUTION TO THE PATHOGENESIS OF MULTIPLE HEREDITARY OSTEOCHONDROMATOSIS. Sheldon A. Jacobson. *The American Journal of Cancer*, XXXIX, 220, June 1940.

Experimental evidence based on histological studies of bone formation in dogs is presented to demonstrate that wherever cartilage and bone, however formed, are growing together, a mutual polarity may result. By virtue of this polarity an epiphysis-like structure is produced. This, if true, would adequately explain the epiphysis-like architecture of cartilaginous exostoses. Three dogs were employed in the experiments. In one instance a fracture was produced through the tibia, and histological studies were made on the thirty-second day. In the other two instances, bladder mucosa was implanted in the rectus muscle to stimulate bone formation.

Photomicrographs are presented, which in part bear out the author's contention that an epiphysis-like arrangement of cartilage and bone occurs.—*Granley W. Taylor, M.D., Boston, Massachusetts.*

THE SCALENUS ANTICUS SYNDROME WITH AND WITHOUT CERVICAL RIB. Joseph Donald and Benjamin F. Morton. *Annals of Surgery*, CXI, 709, May 1940.

The authors present an analysis of twenty-one cases of scalenus anticus syndrome observed by them in the past two years. Sixteen of these twenty-one patients have been operated on by scaleniotomy, of whom fourteen were completely relieved and two partially; the other five are awaiting operation.

The age of these patients ranged from fifteen to fifty-four with an average of thirty-seven years. Females predominated over males. There were nine left-sided cases, eight right-sided, and three bilateral.

Histories revealed that excessive or unusual use of the involved extremity preceding the onset of symptoms occurred in eight cases; five cases were servants who used the arm for sweeping or washing. One case developed immediately after a direct trauma, and two after general anaesthesias during which the shoulder posture was faulty.

The symptoms varied in duration from six weeks to eleven years, half of them existing for less than six months. The outstanding symptoms and physical findings were pain, numbness, tenderness over the scalenus anticus, muscle weakness, and occasionally atrophy. Many cases showed changes in tendon reflexes and sensation. Vascular findings of decreased blood pressure, bruits, and, in severe cases, gangrene were frequently present. Only four had cervical ribs, but the symptoms were more extreme in these cases. A chart summarizing the twenty-one cases is given.

The authors conclude that scaleniotomy is the treatment of choice in scalenus anticus syndrome when conservative treatment is inadequate to give relief; the symptoms are produced by inherent anatomic variations in the shoulder girdle, such as low origin of brachial plexus, etc.; and the precipitating conditions are trauma, occupational strain, or improper posture.—*Frank Kugler, M.D., Iowa City, Iowa.*

THE CERVICOBRACHIAL SYNDROME. A Discussion of the Etiology with Report of Twenty Cases. Kenneth H. Aynesworth. *Annals of Surgery*, CXI, 724, May 1940.

The author proposes that the term "cervicobrachial syndrome" be applied to those cases usually called scalenus anticus syndrome. He believes the suggested nomenclature to be better, because the characteristic symptoms and signs are produced not alone by abnormal function of the scalenus anticus muscle but by various other structures,—for example, cervical rib, normal first thoracic rib, clavicle, cervical nerve trunks, subclavian artery, and sympathetic and vasomotor nerves.

He groups the symptoms into three categories: (1) neurological symptoms,—numbness, pain, paralysis and loss of function; (2) vascular symptoms,—moderate pain, œdema, swelling, obstruction of blood flow with thrombosis and aneurysm formation; and (3) a combination of neurological and vascular symptoms.



In the literature many diverse theories have been produced to explain the etiology of this condition. The author lists and discusses these and favors trauma as the most important contributing element.

Twenty cases are reported, in 80 per cent. of which trauma was present. Twelve patients were treated by section of the scalenus anticus, and all were relieved.—*Frank Kugler, M.D., Iowa City, Iowa.*

**SEMILUNAR CARTILAGES.** Frank P. Strickler. *Annals of Surgery*, CXI, 892, May 1940.

The author describes the mechanism of injury to the internal semilunar cartilage. He points out that in about one-third of the cases, cartilage injury is not associated with locking of the knee joint.

He has devised several instruments to reduce the surgical trauma. These consist of angulated hooks for grasping the cartilage, a right-angle knife for cutting the cartilage, angulated scissors, and two sets of retractors.

He describes his surgical technique, and lays stress on the postoperative treatment. He does not believe in immobilizing the knee, but applies a compression dressing, places the knee slightly flexed on a pillow, and uses ice packs and small amounts of opiates to control pain.

In one or two days after the operation his patients walk with one crutch. He believes that early walking and weight-bearing prevent adhesions, diminish muscle atrophy, and shorten convalescence. His patients are back at work in four or five weeks.—*O. B. Bolibaugh, M.D., San Francisco, California.*

**LEG AMPUTATIONS IN DIABETIC GANGRENE.** Saul S. Samuels. *Annals of Surgery*, CXII, 105, July 1940.

The author states that there are two major indications for amputation in diabetic gangrene: (1) rapidly spreading gangrene with no signs of healing or formation of a line of demarcation, and (2) uncontrollable infection of the foot. All of these cases have inadequate arterial circulation.

The author claims that teaching in the past has been to the effect that closed amputation in these cases is dangerous, because of the likelihood that the infection would spread throughout the body and into the thigh; therefore, guillotine or modified guillotine amputations should be done. (The reviewer does not believe this teaching has been universal.) The author states that the mortality in this type of procedure has been as high as 75 per cent. in some hospitals. He goes on to state that the fear of infection is groundless, and, if a simple procedure is carried out and proper postoperative care is given, the mortality will be low. He also advocates simplification of the preoperative treatment. If the patient is not dehydrated, transfusions and intravenous injections of glucose and saline with insulin coverage are not necessary. If infection is present, it will be difficult or impossible to bring the blood sugar down within normal limits, and delay may be disastrous. Immediate operation should be performed regardless of the diabetic status.

Cyclopropane is the best anaesthetic. If this is not available nitrous oxide should be used. The use of spinal anaesthetics is not advisable.

He describes the method of amputation in detail, including the method of draping. No tourniquet is used. A circular incision is made at the level of the upper border of the patella, at which level the muscles are also cut. Vessels are clamped as they are cut. The sciatic nerve is not injected with alcohol. The femur is sawed through two inches proximal to the level of the skin incision. Vessels are ligated with silk, which is also used to close the muscles and skin. No drains are used.

The patient may be allowed out of bed on the day following the amputation, and may be in a wheel chair every day thereafter. On the sixth or seventh day sutures are re-

moved, and the patient may go home one to four days later. Postoperative care of diabetics is the same as before.

In thirty-three amputations performed by the author the mortality was 9 per cent.

The author describes a similar technique for amputations below the knee.—O. B. Bolibaugh, M. D., San Francisco, California.

**FRACTURE OF THE CAPITELLUM. REPORT OF A CASE SUCCESSFULLY TREATED BY CLOSED REDUCTION.** Edward F. McLaughlin. *Annals of Surgery*, CXII, 122, July 1940.

The author reports a case of fracture of the capitellum successfully reduced by closed manipulation. He describes the method of reduction as follows: Strong traction was placed on the forearm with the elbow in complete extension, and firm pressure over the anteriorly displaced capitellum, the elbow was then brought up quickly into acute flexion at which time the fragment slipped into its proper location. With supervised early active motion and massage, full motion was obtained in about three weeks. A later roentgenogram showed complete healing.

In the literature reviewed, most writers recommended removal of the fragment or open reduction with mechanical fixation. The author of this paper believes that closed reduction with early motion is the method of choice.—O. B. Bolibaugh, M.D., San Francisco, California.

**CYST OF THE SEMILUNAR CARTILAGE.** DeForest P. Willard and Jesse T. Nicholson. *Annals of Surgery*, CXII, 305, Aug. 1940.

The authors report the case of a girl, eleven years old, with a cyst of the internal semilunar cartilage.

They discuss the etiology and pathology. A review of the literature reveals that 200 cases were reported prior to 1939, only thirty cases of which involved the internal semilunar cartilage.

The authors do not believe that trauma plays an important part in the etiology. The microscopic detection of villi, and an endothelial lining would strongly indicate that these cysts result from a developmental fault.—O. B. Bolibaugh, M.D., San Francisco, California.

**AFTER-CARE OF FRACTURES WITH SPECIAL REFERENCE TO DELAYED UNION AND SUDECK'S ATROPHY.** Henry H. Jordan. *Archives of Physical Therapy*, XXI, 25, Jan. 1940.

Thirty-eight years after his original article, in which he described the acute bone atrophy with its typical roentgenographic appearance, Paul Sudeck, as a result of further histological and experimental findings, now believes that the original atrophy named after him is not an atrophy at all and not a pathological condition. It should be called "acute collateral transformation".

While Sudeck considers that the acute collateral bone transformation following fractures, or any injury of sufficient strength, is a regular physiological reaction, is not pathological, and does not require treatment, the author is convinced from his clinical experience that the mottled appearance in the roentgenograms, evident in only a moderate proportion of his cases, indicates an unfortunate disturbance in the healing process. Regardless of the condition of the original lesion, acute collateral bone transformation is almost invariably accompanied by pain and disability on weight-bearing, and continues as long as the roentgenograms show signs of decalcification. Clinically, the appearance of these symptoms indicates that treatment is required.

The writer believes that weight-bearing with adequate walking, and other exercises in an unpadded cast, plus support and more support, is the most effective method of treating this condition. He questions the advisability of local stimulation by physiotherapy.—

C. D. Moffatt, M.D., Iowa City, Iowa.

THE IDENTITY OF MYOTONIA CONGENITA (THOMSEN'S DISEASE), DYSTROPHIA MYOTONICA (MYOTONIA ATROPHICA) AND PARAMYOTONIA. Otto Maas and A. S. Pater-son. *Brain*, LXII, 198, 1939.

These authors traced the conception of the syndrome of myotonia congenita in the literature and examined in detail all those characteristics of the disease which other authors have tried to distinguish from myotonia atrophica. The authors point out that all the cases of myotonia congenita that have been followed over the years have shown changes in the musculature and endocrine disturbances which earmark dystrophia myotonica.

The authors also point out that in cases of paramyotonia, a symptom complex of myotonia, which occurs in cold weather, will reveal that other members of the family have dystrophia myotonica. This disease may be just a variant of the original myotonia congenita.—*L. A. Russin, M.D., Iowa City, Iowa.*

DISLOCATION OF THE INFERIOR RADIO-ULNAR JOINT AS A COMPLICATION OF FRACTURE OF THE RADIUS. Geoffrey Hyman and F. R. R. Martin. *British Journal of Surgery*, XXVII, 481, Jan. 1940.

Ten cases of dislocation of the inferior radio-ulnar joint are described in detail, and fifteen others are discussed briefly. The following classification is made:

"Group I.—Anterior dislocation of the head of the ulna as a component of a severe Colles's fracture.

Group II.—Posterior dislocation of the head of the ulna associated with: (a) fracture of the shaft of the radius (6 cases); (b) fracture of the lower inch of the radius (2 cases).

Group III.—Anterior dislocation of the head of the ulna with fracture of the shaft of the radius (2 cases)."

The treatment is not difficult and can usually be accomplished without open operation. The prognosis for complete recovery is excellent.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

THE AETIOLOGY OF HALLUX RIGIDUS. E. A. Jack. *British Journal of Surgery*, XXVII, 492, Jan. 1940.

In the group of cases studied, this condition was found to precede or to accompany the early stages of pes planus. There was usually evidence of an incompetent first metatarsal segment.

The mechanism by which this defect may be responsible for both conditions is suggested, and this theory is supported by pathological findings.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

A FURTHER REVIEW OF THE INTERINNOMINO-ABDOMINAL OPERATION: ELEVEN PERSONAL CASES. Gordon Gordon-Taylor. *British Journal of Surgery*, XXVII, 643, Apr. 1940.

The writer reviews five cases previously reported and adds six more cases of hind-quarter amputation for sarcoma. New points in technique are mentioned. Death followed operation in four out of eleven cases. Three patients have remained free from disease for eleven, five, and three years respectively. In two, there was recurrence within a year, and in one at the end of five years. The other is a recent case.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

COLLES'S FRACTURE. J. H. Mayer. *British Journal of Surgery*, XXVII, 629, Apr. 1940.

"1. The results of Colles's fractures treated by present methods are extremely disappointing, redisplacement being exceedingly common even after perfect reduction.

2. An essential part of the displacement in most cases is a rotation of the lower radial fragment into supination, but this usually passes unrecognized.

3. The radiological appearances of such a 'supination-twist' are characteristic, and have been enumerated by X-raying experimental fractures in dissected specimens.

4. The triangular fibrocartilage of the inferior radio-ulnar joint plays a vital part in the mechanism of the fracture, and the inferior radio-ulnar joint is probably damaged in the majority of cases. Such damage may be recognized radiologically, and its proper repair must receive due attention.

5. Splintage in full pronation, with the flexed elbow included in the plaster, has proved to be the method of choice as a guard against redisplacement in all cases with a supination-twist and in all with damaged inferior radio-ulnar joints, with the single exception of those with a fracture of the neck of the ulna.

6. The anatomical and functional results in a short series so treated are considerably better than in a consecutive series treated by other methods, and it is hoped that this method will be afforded a more extensive trial."—*Ernest M. Daland, M.D., Boston, Massachusetts.*

A NEW CONCEPTION OF PARATHYROID FUNCTION AND ITS CLINICAL APPLICATION. A PRELIMINARY REPORT ON THE RESULTS OF TREATMENT OF GENERALIZED FIBROCYSTIC AND ALLIED BONE DISEASES AND OF RHEUMATOID ARTHRITIS BY ALUMINUM ACETATE. Arthur J. Helfet. *British Journal of Surgery*, XXVII, 651, Apr. 1940.

The theory is advanced that parathormone exerts its primary effect on the phosphorus metabolism, and that treatment should be based on the control of the phosphorus intake.

A new classification of hyperparathyroidism is offered:

1. Primary hyperparathyroidism due to an adenoma, with fibrocystic disease, high blood calcium, and a low blood phosphorus;
2. Secondary hyperparathyroidism—
  - a. Simple, compensatory, or physiological with normal blood chemistry and either normal or hyperplastic tissue in the gland;
  - b. Pathological, where an adenoma has been superimposed on one of the conditions in the previous group (2, a). This is clinically similar to primary hyperparathyroidism (1) but reverts to the simpler type (2, a) after removal of the adenoma.

A method of lowering the phosphorus intake consists in feeding a soluble salt of aluminum,—aluminum acetate. The dosage and methods of administration are discussed. A pint of milk is also given daily. The same treatment has been used in rheumatoid arthritis on the supposition that this is a type of hyperparathyroidism.

Case reports of four cases of generalized osteitis fibrosa cystica and nine of rheumatoid arthritis treated in this way are given. The results seem to be very satisfactory.—

*Ernest M. Daland, M.D., Boston, Massachusetts.*

OSTEO-ARTHRITIS OF THE HIP. L. W. Plewes. *British Journal of Surgery*, XXVII, 682, Apr. 1940.

A study has been made of 242 cases of osteo-arthritis of the hip. The most common causes were injury, slipped epiphysis, and arthrokataclasis.

Treatment is at first conservative and includes rest, and physiotherapy. Quite recently, deep x-ray therapy has been used with encouraging results. Operative treatment on those failing to improve with conservative measures consists in reconstructive operations, excision of the head and neck of the femur, and arthrodesis.—*Ernest M. Daland, M.D., Boston, Massachusetts.*

UM CASO DE SÍNDROMA DE SUDECK-LERICHE CURADO PELA ACETYLCHOLINE (A Case of Sudeck-Leriche Syndrome Healed by Acetylcholine). F. de Moraes. *Bulletin de la Société Belge d'Orthopédie*, XI, No. 6, July-Aug., 1939.

A case of the syndrome of Sudeck-Leriche or acute painful posttraumatic osteoporosis, is presented in which the paradox sympathectomy of Leriche was replaced by

simple medical treatment, principally injections of acetylcholine. The patient was a woman sixty years of age, who had a distortion of the left foot. Hot air and hot baths, as well as daily injections of 0.10 grams of acetylcholine were prescribed. After the third injection the pain had almost disappeared, and the patient was able to walk with a cane. There was a recurrence of the condition and the patient was again treated by the injection of 0.10 grams of acetylcholine three times a week. After the eighth injection the clinical signs had disappeared. The case presented is typical of posttraumatic osteoporosis and similar cases have been reported by Leriche, Jung, and many others. It seems certain that a novocaine infiltration of the injured ligaments immediately after the accident might have prevented the development of the acute phases of the traumatism.

The author concludes that in the presence of Sudeck-Leriche's syndrome, acetylcholine, hot air and hot baths should be tried before sympathectomy; that the reaction of this hyperaemic therapeutic drug is rapid; and that in case the patient does not respond, the sympathectomy of Leriche is indicated.

Before considering the cure definite and complete, it is necessary to show in the x-ray picture that there is recalcification, although the latter never retains normal intensity.—*Arthur Steindler, M.D., Iowa City, Iowa.*

#### AMPUTATION THROUGH THE LOWER THIRD OF THE FEMUR: A MODIFIED TECHNIQUE.

Clarence E. Rees. *California and Western Medicine*, LIII, 64, Aug. 1940.

A simplified technique is outlined for low amputation of the femur. A circular skin incision is made with the patient in the prone position. The surgeon can thus obtain better accessibility to vessels and nerves, and can secure an excellent flap of tendons, muscles, and fascia with a minimum of trauma and the preservation of the maximum blood supply. A single silk suture is passed through the tendons and tied over the end of the femur. The author reports excellent results from this simplified and rapid technique.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

#### THE CORROSION OF METALS IN TISSUES; AND AN INTRODUCTION TO TANTALUM. George L. Burke. *The Canadian Medical Association Journal*, XLIII, 125, 1940.

In this article, Dr. Burke discusses the question of the corrosion of metals in tissues and the disadvantages of many of the alloys, and tells of the results of his experiments with the use of tantalum. He gives the mechanical properties of tantalum and the analysis of its composition, and states that it is comparable to steel in strength and workability; that unannealed its tensile strength is comparable to that of cold rolled steel, and that, annealed, it is as strong as annealed steel. Tantalum can also be drawn into wire, machined, and variously shaped. The author reports the successful results he has obtained with this metal, notably as suture material.

#### LIPOID GRANULOMATOSIS OF THE BONES WITHOUT SYMPTOMS OF SCHÜLLER-CHRISTIAN DISEASE. I. Snapper. *Chinese Medical Journal*, LVI, 303, 1939.

The author gives a short discussion of Schüller-Christian disease in which are found the characteristics of multiple defect in skull, exophthalmos, diabetes insipidus, and pituitary disturbance.

The author presents three cases with cystic degeneration of various bones in which the calcium, phosphorus, and phosphatase were normal. Each patient had a fracture through the affected zone. There was very slight rise in cholesterol. No exophthalmos, diabetes insipidus, or skull localizations were found. Biopsy through regions of relatively fresh lesions showed xanthoma cells. In one case biopsy was performed three times.—*G. Miyakawa, M.D., Iowa City, Iowa.*

BEOBSACHTUNGEN AN DER KNIEGELENKKAPSEL MITTELS POSITIVER KONTRASTFÜLLUNG UND RÖNTGENDURCHLEUCHTUNG (Observation of the Knee Joint Capsule by the Injection of Contrast Material and X-ray). H. R. Paas. *Deutsche Zeitschrift für Chirurgie, CCLII*, 478, 1939.

The author describes a method of observation of the knee joint by the injection of a contrast material known as "Abrodil" 20 per cent. and "Perabrodil" 35 per cent. Experimental work was done on dogs. Some of his observations and conclusions may be summed up as follows:

The resorption time of the material depends on the age of the patient and the condition of the joint. The faster the resorption, the more acute the inflammation of the joint capsule. As to the physiological state of the joint the examination should show:

1. The tension and space of the joint depending on the position of the joint during the examination. In extension the anterior part of the capsule is in lower tension, and in flexion the posterior part is in lower tension.

2. In a normal state, the capsular apparatus has very marked elasticity, but forceful stretching is not without consequence if applied continuously.

3. In advanced age, and after a long period of non-weight-bearing, there is a structural shortening of the capsule which takes place with loss of elasticity.

The changes mentioned are due to pathological changes of the joint and thus give a complete picture pointing to the lesion. The injected material depends on several conditions. Non-weight-bearing as well as advanced age diminish the ability of the capsule to resorb those materials. Active and passive motion, as well as acute inflammatory processes, increases resorption.—*T. J. Greteman, M.D., Iowa City, Iowa.*

THE PATHOLOGICAL SIGNIFICANCE OF INTRA-ARTICULAR PRESSURE. Ernst Freund.  
*Edinburgh Medical Journal*, XLVII, 192, Mar. 1940.

Under certain pathological conditions such as intra-articular hemorrhage and effusions, the intra-articular pressure, which in the normal joint is negative and amounts to from minus 60 to minus 70 millimeters of water, may increase to a positive pressure up to plus 70 millimeters of water. There may result under such conditions, cystlike excavations invading the epiphysis from the joint, and also a dislocation of the joint contents under the action of weight-bearing and muscular strain. Most severe lesions occur in haemophilic arthritis with destruction of the whole epiphysis. In other forms of arthritis, such as rheumatoid, syphilis, and Charcot's disease, remarkable changes are also encountered. Various types of herniae are described, from a single flasklike excavation with a small opening, to multiple deep cavities, resulting from pressure of long duration. The cells and fibers of the connective tissue of the underlying bone marrow become distended in concentric arrangement with the formation of a capsule. With progression of the herniation, the pressure may be transmitted to adjacent tissues. The bone trabeculae in the way are absorbed by osteoclasts and the cartilage by chondroclasts. The zone of provisional ossification of cartilage not supported by bone, is broken into pieces visible by microscopic examination. If the pressure acts on the side of the bone normally not covered by cartilage, a bay undermining the cartilage results. Here, while absorption is proceeding in the outer layers, there is deposition of new bone on the inner surface. Where the cortex is atrophic, and gaps in the continuity of the bone allow hernial formation, periosteal layers of the synovial membrane may furnish the material for the capsule of the hernia. Contents of the cavity vary from the hematoma in haemophilia to the fibrinoid masses in rheumatoid arthritis. Pieces of detached cartilage and necrotic bone, intermingled with cells, blood, and detritus derived from the joint cavity, are also found.

The course depends upon the balance between the injuring agent and the resistance of adjacent bone tissue. It may go on to extensive destruction or may undergo reparative changes.

The clinical significance of the findings are: (1) Knowledge of lesions is a help in diag-

nosis; (2) increased intra-articular pressure impairs nutrition of the joint structures, especially cartilage; and (3) increased intra-articular pressure produces symptoms distinguishable by ordinary examination.

Treatment should be by prophylaxis; removal of fluid by puncture, drugs, physiotherapy, and dietetics; immobilization; and non-weight-bearing.—*J. Y. Sher, M.D., Iowa City, Iowa.*

**HIGH LIGATION OF THE FEMORAL VEIN IN AMPUTATIONS OF THE LOWER EXTREMITIES. A PRELIMINARY REPORT BASED ON TWENTY-EIGHT AMPUTATIONS OF THE THIGH.** J. Ross Veal. *The Journal of the American Medical Association*, CXIV, 1616, April 27, 1940.

The mortality rate for amputation of the lower extremity is high and out of proportion to other operative procedures.

The author reviewed 171 cases of amputation and found the mortality to be 39.1 per cent.; the majority of deaths were due to pulmonary complications.

Following a study of the anatomy of the leg in relation to blood supply and of the autopsy findings in patients who have submitted to amputation, the author believes these pulmonary complications can be explained on the basis of embolic phenomena. He found the femoral vein to be devoid of tributaries up to the deep profunda in many specimens examined. This resulted in thrombosis up to the deep profunda and some extension of the thrombus into the junction of these two vessels, all of which is conducive to the formation of the emboli.

For this reason the author advises high ligation of the femoral vein just distal to the saphenofemoral junction. Amputations in twenty-eight consecutive cases with low mortality bear out the above theory.—*W. C. Peterson, M.D., Dallas, Texas.*

**PAGET'S QUIET NECROSIS.** J. C. R. Hindenach. *The Lancet*, II, 20, 1939.

There is much confusion among modern authors as to the term "Paget's quiet necrosis". In order to clear this, the writer has quoted the original work of Paget, including his case report in which he describes the process as one of local necrosis and sequestrum formation in the superficial layers of the shaft of a long bone. The lesion is chronic from the beginning, and affects mainly young adults. There is a minimal amount of suppuration surrounding the sequestrum, and sinuses are not formed. It is probably the result of a chronic osteitis due to a rather non-virulent staphylococcus.

The writer quotes descriptions from four modern textbooks of surgery, which show the disagreement between them.—*Frank Kugler, M.D., Iowa City, Iowa.*

**TOXOID TREATMENT OF RECURRENT INFECTION AFTER STAPHYLOCOCCAL OSTEO-MYELITIS.** F. C. O. Valentine and E. C. B. Butler. *The Lancet*, I, 914, May 18, 1940.

The authors studied thirty cases of recurrent staphylococcal infection after osteomyelitis and made an effort to determine the value of a toxoid in maintaining the level of immunity and lessening the tendency toward further attacks. They are of the opinion that osteomyelitis is usually caused by potent leukocidin-producing strains of staphylococcus and they, therefore, think that it is important to use a toxoid containing a potent leukocidal factor. They found that antitoxins in the serum of patients with recurrent staphylococcal infection were seldom high and often within normal limits. They point out that treatment by toxoid injections may sometimes sensitize the tissues, and so precipitate an eruption of a latent focus, but feel that such a focus would probably have become active at some later date when immunity was low. The authors state that it is reasonable to hope that the toxoid will make recurrence less likely and, if it comes, less severe.—*Lenox D. Baker, M.D., Durham, North Carolina.*

TREATMENT OF FRACTURES OF UPPER THIRD OF SHAFT OF FEMUR. J. R. Armstrong. *The Lancet*, I, 957, May 25, 1940.

The author points out that the typical deformity of these fractures—flexion, and abduction of the upper fragment—is caused by the action of the psoas and short muscles inserted on the greater trochanter, while the posterior, inward, and upward displacement of the lower fragment is due to the action of the hamstring and adductor muscles. He condemns the use of the Braun-Böhler frame in this fracture because it does not allow more than 30 degrees of flexion at the hip, which, as the flexion deformity of the proximal fragment is usually about 50 degrees, is insufficient. He advocates the use of a Thomas splint with a bent-knee attachment slung from a Souttar's modification of a Balkan beam to procure traction in the long axis of the femur with the hip in any degree of flexion required. He stresses the importance of having the ring fit closely around the thigh and bear on the posterior surface of the tuberosity of the ischium, in order that the pull of countertraction may be transmitted to the pelvis, and not on the femur below the tuberosity, which would increase the flexion deformity of the proximal fragment. The author warns against early weight-bearing. His methods of applying traction are described in detail, and his paper is well-illustrated.—*Lenox D. Baker, M.D., Durham, North Carolina.*

SULPHAMETHYLTHIAZOLE IN EXPERIMENTAL STAPHYLOCOCCAL INFECTIONS. A. Macdonald. *The Lancet*, I, 1157, June 29, 1940.

The author points out that the use of sulphanilamide and its derivatives in the treatment of staphylococcus aureus infections in man has been disappointing. He studied the efficacy of sulphamethylthiazole in staphylococcus infections in mice. From his experiments with 200 mice, he concluded that both sulphamethylthiazole and sulphapyridine given by mouth prevented many of the early deaths in experimental staphylococcus infections in mice but are less efficient after abscesses have begun to form; that none of the sulphanilamide drugs is particularly active in the presence of pus; and that the experiments with skin abscesses may indicate that sulphamethylthiazole does not completely overcome this difficulty.—*Lenox D. Baker, M.D., Durham, North Carolina.*

CLOSED PLASTER TREATMENT OF INFECTED WOUNDS. G. R. Girdlestone. *The Lancet*, II, 31, July 13, 1940.

The author points out that the success of the closed plaster method depends on its correct application to the individual case. He calls attention to the necessity of proper débridement, and the proper application of the cast in order that an even, gentle pressure, similar to that normally exercised by the fasciae and the skin, is exerted over the exposed tissues. He warns against condemning the method because it has failed in the hands of surgeons imperfectly familiar with the method. He states, "He who would apply plaster in war must be skillful in its use, or he will be a danger to his patients and bring undue discredit on the method; he had far better continue to treat wounds on more familiar lines. . . . If a wound is to do well it must first be given appropriate operative treatment: after this the progress of the wound and the comfort of the patient depend on the fit and inner smoothness of the plaster."—*Lenox D. Baker, M.D., Durham, North Carolina.*

THE CLASSIFICATION OF REPRINTS OF ARTICLES IN AN ORTHOPAEDIC LIBRARY. Sidney Pappworth. *The Liverpool Medico-Chirurgical Journal*, XLVI, Part II, 144, 1939.

In this article Mr. Pappworth describes the system which he devised for use in the Hugh Owen Thomas and Robert Jones Memorial Library at the Liverpool Medical Institution, in which there are an extremely large number of books and reprints.

The author discusses the defects and difficulties met with in the various systems of classification now in use, and the need of some method which not only the library, but the surgeon may follow in filing literature in order to allow easy reference at any time.



He states that the system of the British Orthopaedic Association is too broad in its grouping and that it is one of diseases only, and, therefore, does not allow in the classification other conditions which it is necessary to include.

Mr. Pappworth's system, with certain additions, is based on diseases with groupings and subgroupings arranged, as he says, in the order which he would use if he were writing a textbook on orthopaedic surgery. He then gives his classification, including the main and the subgroups and the contents of each. The simplicity of the system will appeal to the physician, as will the means advocated for adding subjects not classified under disease.

This method of classification should be of use to the orthopaedic surgeon, and the system is applicable to any department of medicine or surgery. Those interested in the difficult problem of filing reprints should certainly consult this article.

DÉBRIDEMENT. M. R. Charlton. *The Military Surgeon*, LXXXV, 129, 1939.

Early in the World War the only patients operated upon were those with hemorrhage, severe wounds needing amputation, wounds of the skull and viscera, and those of long standing with fully developed infection. Other wounds were treated expectantly, that is, were expected to become infected—and they did. The results were bad in regard to mortality, permanent disability, and prolonged hospital care. In débridement, which began in the War in 1914, the tract is first mapped out; healthy tissue cut with anatomical sharp dissection; and devitalized tissue, foreign bodies, and muscle, which is infiltrated with blood and does not contract when pinched with forceps, removed. Bone fragments are removed freely in compound fractures. The wounds are packed with gauze and most of them left open. The author believes that even well-trained civilian surgeons find difficulty with military débridement, the evacuation-hospital operation. He gives the contra-indications and indications for débridement as follows:

1. Clean, perforating wounds of soft parts, by rifle or machine gun bullet, not involving nerves, blood vessels, or bone do not need débridement.
2. No débridement is usually required for compound fractures by perforating bullets unless there is extreme comminution.
3. Superficial gutter wounds not involving muscles may be treated conservatively.
4. All obviously infected or badly lacerated wounds, those with foreign bodies, or involving blood vessels, nerves, or bone, and all wounds of the skull and contents require immediate operation.
5. All perforating or penetrating wounds of the abdomen need débridement.
6. Continued hemorrhage is the criterion for operation in chest wounds.
7. Wounds from high explosives need rigorous treatment, as shell fragments cause damage out of proportion to their size.—*Samuel Levine, M.D., Iowa City, Iowa.*

ARTIFICIAL LIMBS. A. Steindler. *The Military Surgeon*, LXXXVI, 560, June 1940.

The writer describes the historical development of the artificial limb. He mentions the increasing use of these prostheses in the modern day, due to war and civil injuries. In the United States the annual demand is now 22,500.

General principles of amputation are discussed, including sites of amputation, prevention of contractures, rules for after-treatment, and types of bearing points. In conclusion, materials and methods of construction of prostheses are given.—*Frank Kugler, M.D., Iowa City, Iowa.*

MARCH FOOT. Henry W. Meyerding and George A. Pollock. *The Military Surgeon*, LXXXVI, 593, June 1940.

These writers describe the symptoms, physical findings, roentgenograms, and treatment of march foot. They believe that overloading a foot already weakened functionally

and anatomically, is the most plausible theory of causation. The condition occurs during long marches when the foot is excessively fatigued. They describe the hair-line character of the fracture seen in the roentgenogram, and caution against overlooking it. When seen late, the lesion may resemble a tumor in the roentgenogram, and then a biopsy is required for diagnosis. Immobilization in plaster is the treatment recommended.—

*Frank Kugler, M.D., Iowa City, Iowa.*

DIE DEUTUNG DES KAHNSBEINSPALTES IM WANDEL DER ZEITEN (Changing Interpretation of the Scaphoid Fissure). Fritz Reckling. *Beihefte zur Monatsschrift für Unfallheilkunde und Versicherungsmedizin*, Hefte 29, 1940.

The author reviews the various theories which have been advanced to explain the appearance of the fissure in the carpal scaphoid. This condition was first seen and described in 1865 by Gruber who considered the bipartite scaphoid to be a developmental arrest. Pfizner considered it a reversion to an old condition of separation between the "ulnar scaphoid" and the "radial scaphoid". Still others are inclined to consider the bipartite condition as a pseudarthrosis, resulting from injury.

A lengthy discussion of the relative merits of each theory, with references for and against each, is presented. A critique of diagnostic procedures is suggested, but at the end the question still remains unanswered.—*Henry Milch, M.D., New York, N. Y.*

CONTRIBUTO ALLA TERAPIA DELLA OSTEODISTROFIA FIBROSA CIRCOSCRITTA (Contribution to the Treatment of Localized Osteitis Fibrosa Cystica). R. Memmi. *Ortopedia e traumatologia dell'apparato motore*, XI, 1, 1939.

The author reports twenty cases of the localized type of osteitis fibrosa cystica which obviously is divorced entirely from the generalized form. The condition was brought to light by a pathological fracture. He has seen cases with only partial healing of the lesion after the initial fracture, have complete healing after a second fracture occurred. After a fracture, the fibrous tissue ossifies by metaplasia in a manner analogous to the healing of fractures by callus. The healing after fracture was observed to last from three to six years. In two cases a progression of the lesion, instead of healing, took place. The author's observations disagree with those of Tavernier who feels that fracture has no favorable influence on localized osteitis fibrosa cystica. If fracture does not aid healing in such cases, the author feels that in spite of roentgenographic indications the histology of the lesion may be quite different from a localized osteitis fibrosa cystica. He states that, of course, giant-cell tumors are quite different, and are not benefited by a pathological fracture.

There seems to be no unanimity of opinion regarding treatment. The general tendency is toward open operation, though spontaneous healing has occurred on rare occasions. Geschickter and Copeland recently advocated fracturing the bone to produce healing, but the author argued that there was no point in scraping out these cavities which contain osteogenetic tissue. He, therefore, employed multiple perforations into the tumor. Perforations repeated after thirty to forty days gave clinical proof of improvement by the increased resistance of the tissue.

He obtained complete healing by this method in five cases, three of which had been treated unsuccessfully by curettage, bone graft, parathyroidectomy, and packing with chalk and iodoform, and feels that perforation of the cyst may become the method of choice in treating this lesion.—*A. W. Ciani, M.D., Iowa City, Iowa.*

LA CURA CHIRURGICA DELLA TUBERCOLOSI DI SPALLA (The Surgical Treatment of Tuberculosis of the Shoulder). F. Mandruzzato. *Ortopedia e traumatologia dell'apparato motore*, XI, 53, 1939.

The author presents the indications and technique for resection and arthrodesis of the tuberculous shoulder. He favors resection wherever possible, and reserves arthro-

desis for cases which are so benign that resection might be considered too radical, or in which, after the disease is quiescent, painful incongruity of the shoulder joint or tension on the brachial plexus is present. Extra-articular arthrodesis is employed when there is danger of interfering with growth, when it is difficult to remove all the diseased bone, or when there is doubt that the quiescent stage has been reached.

The technique of resection is described. A total synovectomy is performed. A groove is made in the greater tuberosity, and the acromion, after its lower half has been resected, is imbedded in it. The patient is kept in a shoulder spica for six to eight months, and later in a celluloid splint at night.

For arthrodesis the author follows the technique of Delitala which, together with resection of the joint surfaces, may be used for a combined intra-articular and extra-articular fusion.

Of the fifteen cases reported, one-half of which were between the ages of twenty and thirty years; seven were resections, five combined intra-articular and extra-articular fusions, and three were extra-articular fusions.

Twelve patients were followed for from two to nine years. All had complete relief from pain and, with one exception, complete bony ankylosis. This one patient had no pain and a firm fibrous ankylosis which was recognized only in the roentgenogram. All patients were able to return to their former work, some doing heavy labor, without difficulty.

Of the other three, two had been operated on too recently to be reported, and one had died of miliary tuberculosis in six months.

The optimum position was 80 degrees abduction with 25 degrees forward flexion.

In view of the excellent results the author strongly favors the surgical over the conservative treatment of the condition.—A. W. Ciani, M.D., Iowa City, Iowa.

#### RESULTS OF CLOSED REDUCTION OF CONGENITAL DISLOCATION OF THE HIP. R. Memmi. *Ortopedia e traumatologia dell'apparato motore*, XI, Apr. 1939.

The author reports ninety-eight cases treated by closed reduction and followed for from two to thirteen years. The Paci-Lorenz manoeuvre was employed and the hips kept in the primary position for from two to five months, and in the secondary position one and a half to four months, with about three to four weeks in the intermediate position.

The difference between the two sexes was very marked; eighty-six were females and twelve were males.

Fifty per cent. gave immediate good results, 33.67 per cent. fair, and 16 per cent. poor results. A large proportion of the immediate good results, and smaller proportions of the fair and poor results were in patients under the age of three years. Of the long-range results half were still good, but some of the immediate fair results became poor. About 80 per cent. of the patients over the age of five years gave poor results, and the author feels that the use of closed reduction is too great a risk in these cases.

A small group of patients with immediate good results showed a tendency toward coxa plana and later had mediocre results; but a small group, under the age of three years, with immediate mediocre results, had subchondral lesions which eventually healed, and later showed good results. The patients with early mediocre results and later poor results were those with a coxa vara or insufficient regeneration of the acetabulum, and an incongruity of the head, who were treated after the age of three years. In the patients of this group, totalling 10 per cent., redislocations or degenerative arthritis developed. The vast majority of cases of coxa valga and coxa plana occurred in patients under three years of age, whereas most of the arthritis and coxa vara cases were found in patients over that age.

The results in unilateral cases were 20 per cent. better than in the double dislocations, in both the early and long-range statistics.

The author's results indicated a direct relation between the severity of the dislocation and the possibility of a good result. He found that a five-year follow-up is the minimum for an accurate prognosis.

His criteria for good results are absence of pain and limp, complete range of hip motion in all directions, good morphology of the head and acetabulum, and normal relation of the components of the hip joint. A slight flattening of the femoral head is permissible if the other requirements are met. Mediocre results are indicated by easy fatigability and pain on weight-bearing, a diminution of the range of motion, and degenerative changes in the head and acetabulum. In this group, varying degrees of coxa plana, underdevelopment or regression of the superior portion of the acetabulum, and coxa vara were found. The poor group included redislocations, degenerative arthritis resulting from profound morphological skeletal changes incompatible with free function, pain, contractures, marked interference with weight-bearing and gait.—

A. W. Ciani, M.D., Iowa City, Iowa.

SUR ONZE OBSERVATIONS DE TUBERCULOSE SOUS-ASTRAGALIENNE CHEZ L'ADULTE JEUNE (Eleven Cases of Subtalar Tuberculosis in the Young Adult). R. Dubau and F. Bolot. *La Presse Médicale*, XLVIII, 519, May 21, 1940.

Among thirty cases of tuberculosis of the foot, eleven involved the subtalar joint. The principles of diagnosis are discussed. Attention is called to the fact that in the presence of a subtalar arthritis, a positive sputum is presumptive evidence of the tuberculous nature of the disease. The authors point out that the subtalar joint consists of two parts, which are completely separated by the tarsal ligament of Parabeuf. The anterior portion of the subtalar joint is usually in connection with the midtarsal joint. The posterior portion occasionally communicates with the ankle joint, but infection in this joint is usually by contiguity. Isolated infection of the posterior part of the joint may occur. Isolated infection of the anterior subtalar joint is impossible. The prognosis is good, except when the Chopart joint is involved.

The treatment is of the accepted type. A simple means of fusing the subtalar joint by driving a bone graft through both talus and os calcis is illustrated.—Henry Milch, M.D., New York, N. Y.

HAND-SCHÜLLER-CHRISTIAN SYNDROME. P. E. Thompson Hancock. *Proceedings, Royal Society of Medicine*, XXXII, 1386, 1939.

Case report of a female, age eighteen, with a history of a spontaneous fracture of the upper end of the left humerus at the age of three, associated with previous ill health. There was generalized lymphadenopathy. Operative procedure disclosed a yellow gelatinous growth at the site of fracture. A bone graft was done. At the age of six years two tumors appeared in the skull which were treated with radium. Four years later further skull tumors developed in the frontal and parietal regions. These also were treated with radium. At the age of eleven, there was a spontaneous fracture of the right femur. X-rays at Royal Cancer Hospital in 1934, eleven years after onset, suggested Hand-Schüller-Christian's syndrome with areas of rarefaction in the skull and a cyst in the neck of the right femur. Blood phosphorus, calcium, and sugar were normal. Blood cholesterol was 189 milligrams. Patient was given high-voltage therapy. In 1937 she developed slight proptosis of both eyes, inequality of pupils, left facial palsy, bilateral nerve deafness, and atrophy of the right half of the tongue. Her mental condition was good. There were no symptoms of diabetes insipidus. The family history was negative. On examination there was a flail left arm, torticollis, and marked scoliosis. Patient was able to walk.—S. Albert, M.D., Iowa City, Iowa.

PAGET'S DISEASE WITH PARAPLEGIA. J. St. C. Elkington. *Proceedings, Royal Society of Medicine*, XXXII, 1420, 1939.

Case report of a seventy-year-old man with history of gradually increasing weakness of both legs, especially the right; numbness, beginning in feet and gradually spreading up to the umbilicus. Increasing constipation and difficulty in voiding were noted.

Examination revealed no obvious bony deformity. There was moderate spasticity of both legs with corresponding weakness of flexor muscles, and some wasting of the quadriceps bilaterally. Abdominal reflexes were absent; knee jerks, accentuated, and ankle jerks, absent. There was a bilateral Babinski. All forms of cutaneous sensibility were diminished in the lower extremities and the lower part of the trunk. X-rays of the skull, spine, and pelvis showed the advanced changes of Paget's disease.

Of two previous cases of Paget's disease seen by the author, both of which involved the cord, one responded quickly to laminectomy; the other, not at all.—*S. Albert, M.D., Iowa City, Iowa.*

**SYNOVECTOMY OF THE KNEE JOINT.** F. Walter Carruthers. *Southern Medical Journal*, XXXIII, 550, May 1940.

This is a report of thirty-four synovectomies performed for two cases of chronic hypertrophic villous arthritis; four of chronic arthritis; eight of chronic synovitis; and fourteen of chronic infectious arthritis. Six were bilateral. Ages ranged from eighteen to sixty-nine years. Wounds were closed. No fixation except a simple Buck's extension was used for the first ten days. At the end of six weeks the patients were usually up and walking with the aid of a cane or crutches. Heat and light massage were used in the convalescent period. More than ninety-five per cent. of the cases were relieved. End results showed: twenty-two very satisfactory, two fair, six improved. Four became ankylosed but were relieved of pain.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

**THE ROENTGENOLOGIC BONE MANIFESTATIONS IN CERTAIN GENERALIZED DISEASES OF INFANTS AND CHILDREN.** W. D. Anderson and James G. Hughes. *Southern Medical Journal*, XXXIII, 660, June 1940.

The material in this article is classified under five headings: (1) congenital anomalies which include Albers-Schönberg disease (osteopetrosis or marble bones), osteogenesis imperfecta (fragilitas ossium), and chondrodystrophia foetalis (achondroplasia); (2) infections, limited to syphilis; (3) endocrine disturbances; (4) metabolic disturbances which include rickets, scurvy, and xanthomatosis (Hand-Schüller-Christian syndrome and chronic Gaucher's disease); (5) changes due to chemicals such as lead, phosphorus, bismuth; and (6) anaemias which cover sickle-cell anaemia and erythroblastic anaemia.

Roentgenograms of the long bones often give helpful hints in the diagnosis of these conditions.—*Fred G. Hodgson, M.D., Atlanta, Georgia.*

**DIAGNÓSTICO RADIOGRÁFICO DEL MAL DE POTT DORSOLUMBAR** (The Roentgenographic Diagnosis of Dorsolumbar Pott's Disease). Carlos E. Ottolenghi. *Revista de Ortopedia y Traumatología*, VIII, 394, 1939.

In the diagnosis of dorsolumbar Pott's disease, the author emphasizes the following points which are all brought out in the roentgenograms: the early appearance of the lesion, spondylitic scoliosis, narrowing of the intervertebral disc, herniation of the disc into the body of the vertebra, central lesion with collapse, multiple and irregular foci, mediastinal abscess, extended destructive lesion with angulation, and diffuse lesions extending over several vertebrae.

For differential diagnosis, dorsolumbar Pott's disease is contrasted with vertebral epiphysitis, metastases of diffuse carcinomatosis of the vertebrae, tabetic arthropathies, hemivertebrae, and particularly the osteomyelitis and infectious spondylitis with osteophytic periosteal reaction.

In one case of Pott's disease the author demonstrates the central cavity of the vertebral body, which had not changed its normal form and showed only the presence of the large carious zone in its interior. In another form the disease is localized in the posterior arches. In the roentgenogram this is seen as loss of substance at the level of the lamina and pedicle, similar to that observed in cases after a hemilaminectomy.

His varied material demonstrates the polymorphous character of tuberculosis.—*Arthur Steindler, M.D., Iowa City, Iowa.*

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